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ABSTRACT

This document presents information about the apprenticeship training program of Alberta, Canada, in general and the communication technician program in particular. The first part of the document discusses the following items: Alberta's apprenticeship and industry training system; the apprenticeship and industry training committee structure; local apprenticeship committees; provincial apprenticeship committees; the Alberta Apprenticeship and Industry Training Board; safety education; legal and administrative aspects of safety; the technical training establishment; procedures for recommending revisions to the course outline; and a communication technician training profile. The second part of the document presents the course outline for the following sections of the program: first period technical training (trade introduction/safety/work plans; basic electricity; trade mathematics; cable; bonding and grounding; telephony); second period technical training (electronics; applied mathematics; building wiring requirements; logic circuits; basic transmission; fiber optics fundamentals); third period technical training (data communications; multiplexing; noise mitigation; direct current power plants; computers); and fourth period technical training (voice networks; local area network and wide area network, transmission systems; wireless systems). The times allotted for each of the topics to be covered in each course component are detailed. (MN)

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APPRENTICESHIP TRAINING

ED 476 356

Communication Technician Program

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Communication Technician

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Course Outline

First Period Technical Training 12
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Apprenticeship and Industry Training System

Apprenticeship is post-secondary education with a difference. It helps ensure Alberta has a steady supply of highly-skilled employees, the foundation of our economy's future health and competitiveness.

Apprentices in more than 50 trades and crafts spend between one and four years learning their trade - 80% of the time on the job under the supervision of a certified journeyman or qualified tradesperson. The balance of the program is technical training in the theory, skills and technologies of their trade.

To become certified journeymen apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board (the Board) and a network of local and provincial industry committees.

The graduate of the Communication Technician apprenticeship training is a journeyman who will be able to responsibly do all work tasks expected of a journeyman.

- supervise, train and coach apprentices.
- use a thorough knowledge of electrical and electronic theory and its application to communication and associated equipment used in the telecommunication industry.
- understand different circuit combinations and components
- use competently test instruments and understand their capabilities and limitations.
- competently with dexterity and skill carry out the mechanical functions required when completing repairs.
- competently use test procedures to locate faults and isolate defective components.
- read and interpret drawing, plans and specifications and layout and develop projects according to specifications.
- co-ordinate communication work within the scope of the Communication Technician trade and other trades employed in the industry in both installation and maintenance.
- perform assigned tasks in accordance with quality and production standards required in industry.

Apprenticeship and Industry Training Committee Structure

While government supports Alberta's apprenticeship and industry training system, it is driven by industry, a term which includes both employers and employees. The Alberta Apprenticeship and Industry Training Board, with the support of Alberta Learning, oversees the system. But the system relies on a network of industry committees. These committees include local and provincial apprenticeship committees (LACs and PACs) in the designated trades and occupational committees in the designated occupations, as well as other committees such as provisional committees established before the designation of a new trade or occupation comes into effect. All these committees are composed of equal numbers of employers and employees. The network of industry committees is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the Board can set up a LAC. The Board appoints equal numbers of employees and employers for terms of up to three years. The committee appoints a member as presiding officer. Local Apprenticeship Committees:

- monitor the apprenticeship system, and the progress of apprentices in their trade, at the local level.
- help settle certain kinds of issues between apprentices and their employers.
- recommend improvements in apprenticeship training and certification to their trade's provincial apprenticeship committee.
- make recommendations to the Board regarding the appointment of members to their trade's PAC.

Provincial Apprenticeship Committees (PAC)

The Board establishes a PAC for each trade and, based on PAC recommendations, appoints a presiding officer and equal numbers of employees and employers for terms of up to three years. Most PACs have nine members. Provincial Apprenticeship Committees:

- identify the training needs and content for their trade.
- recommend to the Board the standards for training and certification for their trade.
- monitor the activities of local apprenticeship committees in their trade.
- make recommendations to the Board about the designation of trades and occupations.
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in the trade.
- may participate in resolving any apprenticeship-related disputes between employers and employees.

Communication Technician PAC Members

Mr. T. Hyman	Edmonton	Presiding Officer
Mr. J. Barnes	Bonnyville	Employer
Mr. R. Pearson	Calgary	Employer
Mr. M. Semeniuk	Edmonton	Employee
Mr. L. Steparyk	Edmonton	Employee
Mr. J. Guss	Calgary	Employee
Mr. R. Williams	Edmonton	Employee

The Alberta Apprenticeship and Industry Training Board (Board)

The mandate of the Alberta Apprenticeship and Industry Training Board relates to the standards and requirements for training and certification in programs under the *Apprenticeship and Industry Training Act*. The Board provides advice to the Minister of Learning on the training and certification of people in designated trades and occupations and on the needs of the Alberta labour market for skilled and trained persons. The Board also makes orders and regulations respecting standards and requirements for apprenticeship programs and the training of apprentices and for training and certification in designated trades and occupations, and the criteria or requirements for granting and recognizing trade and other certificates.

The 13-member Board consists of a chairman, eight members representing trades and four members representing other industries. The trades and other industry members are equally represented by employer and employee representatives.

Safety Education

Safe working procedures and conditions, accident prevention and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees and the public. Therefore, it is imperative that all parties become aware of circumstances that may lead to injury or harm. Safe learning experiences and environments can be created by controlling the variables and behaviours that may contribute to or cause an accident or injury.

It is generally recognized that a safe attitude contributes to an accident free environment. Everyone will benefit as a result of a healthy, safe attitude towards prevention of accidents.

A tradesperson is possibly exposed to more hazards than any other person in the work force and, therefore, should be familiar with and apply the Occupational Health and Safety Act and Regulations dealing with personal safety and the special safety rules applying to each task.

Legal and Administrative Aspects of Safety

Accident prevention and the provisions of safe working conditions are the responsibilities of an employer and employee.

Employer's Responsibilities

The employer is responsible for:

- providing and maintaining safety equipment, and protective devices and clothing.
- enforcing safe working procedures.
- providing safeguards for machinery, equipment and tools.
- observing all accident prevention regulations.
- training employees in the safe use and operation of equipment.

Employee's Responsibilities

The employee is responsible for:

- working in accordance with the safety regulations pertaining to the job environment.
- working in such a way as not to endanger themselves or fellow employees.

Workplace Health and Safety's Responsibilities:
Workplace Health and Safety (Alberta Human Resources and Employment) will conduct periodic inspections of the workplace to ensure that safety regulations for industry are being observed.

Technical Training Establishment

Alberta Learning, Apprenticeship and Industry Training offer your apprenticeship training program. Staff and facilities for delivering the program are supplied by Northern Alberta Institute of Technology

Procedures For Recommending
Revisions To The Course Outline

Apprenticeship and Industry Training, Industry Programs and Standards has prepared this course outline in partnership with the Communication Technician Provincial Apprenticeship Committee.

This course outline was approved on November 1, 2002 under the authority of the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. Valuable input is acknowledged from industry, Local Apprenticeship Committees and the Technical Training Establishments.

Any concerned citizen or group in the Province of Alberta may make recommendations for change by writing to:

Communication Technician Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
10th floor, Commerce Place
10155 - 102 Street
Edmonton, AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations received will be placed before regular meetings of the Provincial Apprenticeship Committee.

COMMUNICATION TECHNICIAN TRAINING PROFILE

First Period
(240 Hours)

SECTION ONE

TRADE INTRODUCTION/SAFETY/ WORK PLANS
8 Hours

A	B	C
Trade Scope 0.5 Hours	Personal Safety 1 Hour	Hazardous Materials 1 Hour
D	**E**	**F**
Confined Space Entry 1.5 Hours	Trenching 0.5 Hours	Fall Arrest 0.5 Hours
G		
Work Plans 3 Hours		

SECTION TWO

BASIC ELECTRICITY
104 Hours

A	B	C
Electricity Fundamentals 3 Hours	Ohm's Law 3 Hours	DC Circuits 18 Hours
D	**E**	**F**
Analytical Troubleshooting 2 Hours	Direct Current Meters 4 Hours	Conductors /Insulators 2 Hours
G	**H**	**I**
Resistors 2 Hours	Batteries 3 Hours	Magnetism 4 Hours
J	**K**	**L**
Induction 3 Hours	Relays 2 Hours	Alternating Current & Voltage 6 Hours
M	**N**	**O**
Inductive Circuits 6 Hours	Capacitive Circuits 6 Hours	RLC in AC Circuits 4 Hours
P	**Q**	
Resonance 4 Hours	Basic Electricity Lab 32 Hours	

SECTION THREE

TRADE MATHEMATICS
24 Hours

A	B	C
Review of Basic Arithmetic 10 Hours	Advanced Topics 6 Hours	Trigonometry 8 Hours

SECTION FOUR

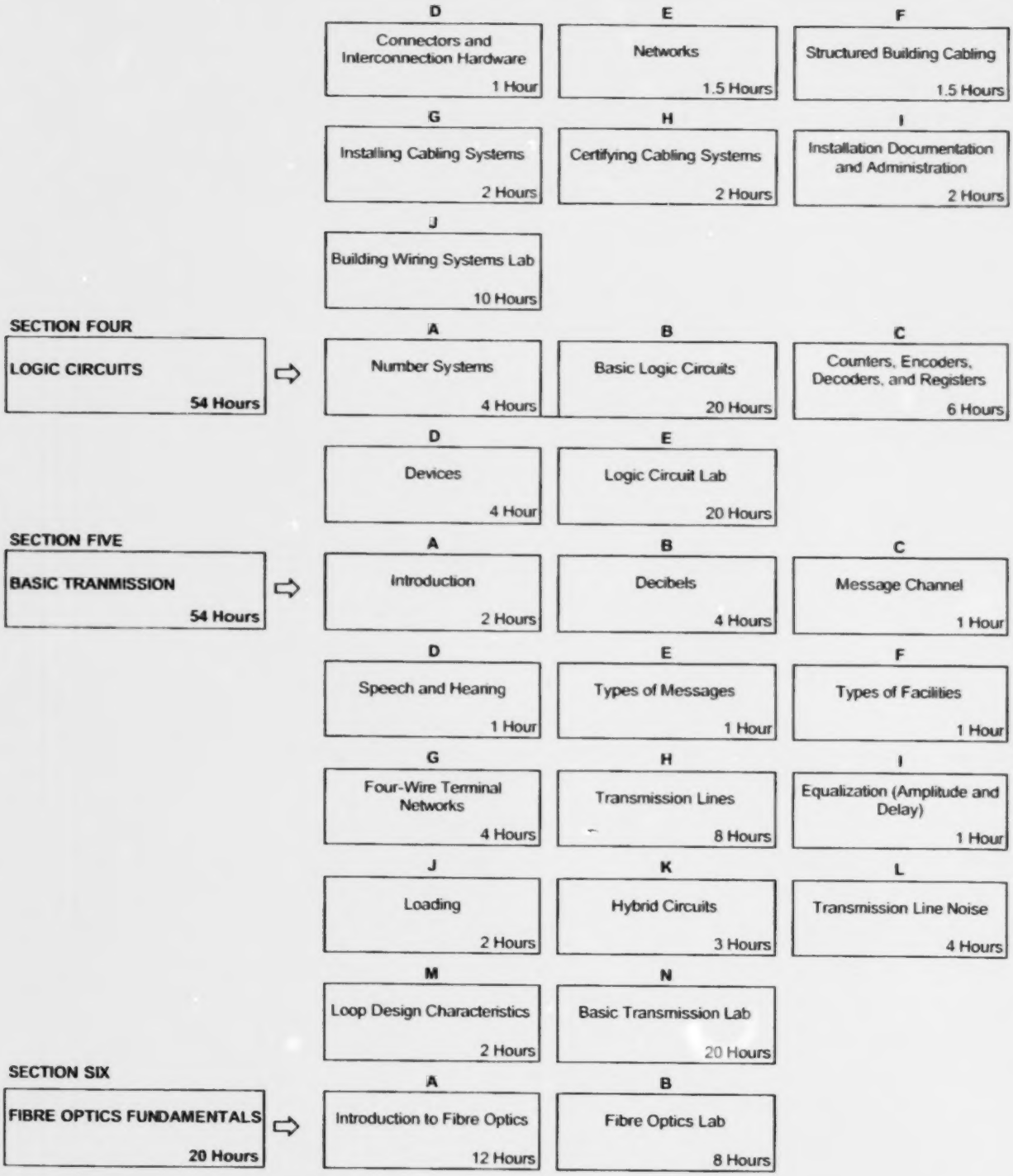
CABLE
64 Hours

A	B	C
Cable development 1 Hour	Cables and Conductors 7 Hours	Splicing Theory 14 Hours

	D Cable Loading 2 Hours	E Splice Closures 2 Hours	F Cable Splicing Lab 20 Hours
	G Line Theory 8 Hours	H Cable Pressurization 10 Hours	
SECTION FIVE **BONDING AND CROUNDING** **16 Hours** ⇨	A Bonding and Grounding 10 Hours	B Station Protection 5 Hours	C Central Office 1 Hour
SECTION SIX **TELEPHONY** **24 Hours** ⇨	A Basic Telephone Line 2 Hours	B Basic Telephone Set 3 Hours	C Telecommunications Systems 3 Hours
	D Basic Switching System Functions 6 Hours	E Basic Customer Terminal Equipment 2 Hours	F Basic Telephony Lab 8 Hours

Second Period
(240 Hours)

SECTION ONE **ELECTRONICS** **64 Hours** ⇨	A Introduction 5 Hours	B Diodes 3 Hours	C Power Supplies 4 Hours
	D Junction Transistors 2 Hours	E Transistor Biasing 3 Hours	F Small Signal Amplifiers 7 Hours
	G Power Amplifiers 3 Hours	H Oscillators 3 Hours	I Field Effect Transistor (FET) 3 Hours
	J IC Operational Amplifier 9 Hours	K Pulse Theory 5 Hours	L Advanced Electricity Lab 17 Hours
SECTION TWO **APPLIED MATHEMATICS** **24 Hours** ⇨	A Exponents and Radicals 8 Hours	B Logarithms 8 Hours	C Complex Numbers 8 Hours
SECTION THREE **BUILDING WIRING REQUIREMENTS** **24 Hours** ⇨	A General Requirements 1 Hour	B Copper Cables 2 Hours	C Fibre Optics 1 Hour


D
Connectors and Interconnection Hardware
1 Hour
E
Networks
1.5 Hours
F
Structured Building Cabling
1.5 Hours
G
Installing Cabling Systems
2 Hours
H
Certifying Cabling Systems
2 Hours
I
Installation Documentation and Administration
2 Hours
J
Building Wiring Systems Lab
10 Hours
SECTION FOUR
LOGIC CIRCUITS
54 Hours
A
Number Systems
4 Hours
B
Basic Logic Circuits
20 Hours
C
Counters, Encoders, Decoders, and Registers
6 Hours
D
Devices
4 Hour
E
Logic Circuit Lab
20 Hours
SECTION FIVE
BASIC TRANMISSION
54 Hours
A
Introduction
2 Hours
B
Decibels
4 Hours
C
Message Channel
1 Hour
D
Speech and Hearing
1 Hour
E
Types of Messages
1 Hour
F
Types of Facilities
1 Hour
G
Four-Wire Terminal Networks
4 Hours
H
Transmission Lines
8 Hours
I
Equalization (Amplitude and Delay)
1 Hour
J
Loading
2 Hours
K
Hybrid Circuits
3 Hours
L
Transmission Line Noise
4 Hours
M
Loop Design Characteristics
2 Hours
N
Basic Transmission Lab
20 Hours
SECTION SIX
FIBRE OPTICS FUNDAMENTALS
20 Hours
A
Introduction to Fibre Optics
12 Hours
B
Fibre Optics Lab
8 Hours

10

Third Period
(240 Hours)

SECTION ONE

DATA COMMUNICATIONS
88 Hours

A	B	C
Overview of Data Communications 2 Hours	Communications Coding Structure 8 Hours	Terminals 2 Hours
D	**E**	**F**
Electrical Characteristics of Digital Signals 6 Hours	Network Access Devices 8 Hours	Communication Links and Modes of Operation 2 Hours
G	**H**	**I**
Introduction to Data Communication Equipment 2 Hours	Digital Data Networks 2 Hours	Protocols 6 Hours
J	**K**	**L**
Analog Data Communications Channel 4 Hours	Bandwidth Manager 8 Hours	Communication Networking Techniques 6 Hours
M		
Data Lab 32 Hours		

SECTION TWO

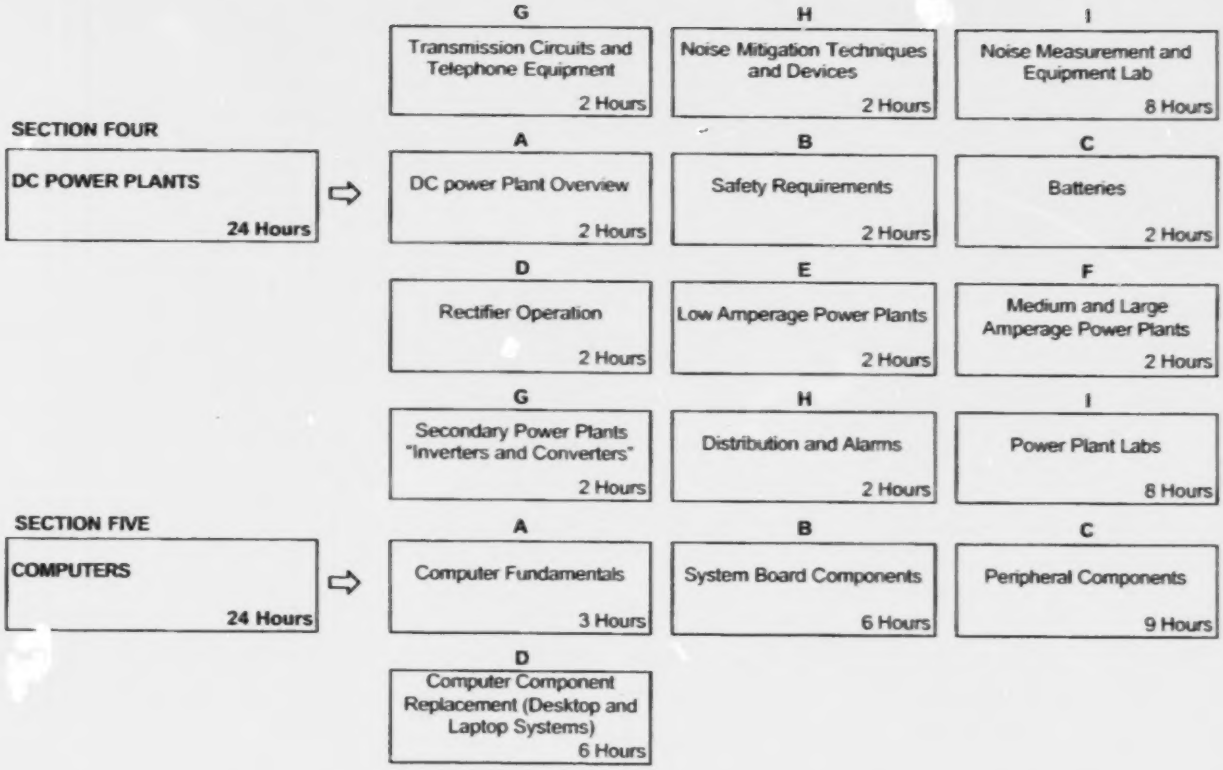
MUTIPLEXING
80 Hours

A	B	C
Introduction to Networking 4 Hours	Simple Toll Circuit Sub to Sub (Digital Multiplexing) 4 Hours	Subscriber Interfacing 4 Hours
D	**E**	**F**
Basic Signalling 2 Hours	Introduction to Digital Multiplexing 4 Hours	Fundamentals of Pulse Code Modulation (Digital Multiplexing) 6 Hours
G	**H**	**I**
PCM Channel Bank (Typically Manufactured Digital Multiplexers) 10 Hours	Line Codes 4 Hours	Fundamentals of T1 Repeatered Lines (Digital Multiplexing) 4 Hours
J	**K**	**L**
Digital Hierarchy (Digital Multiplexing) 6 Hours	T3 Line Signal Characteristics 2 Hours	Higher Order PCM 4 Hours
M	**N**	
Higher Order Digital Transport Systems 4 Hours	Digital Multiplexing Lab 22 Hours	

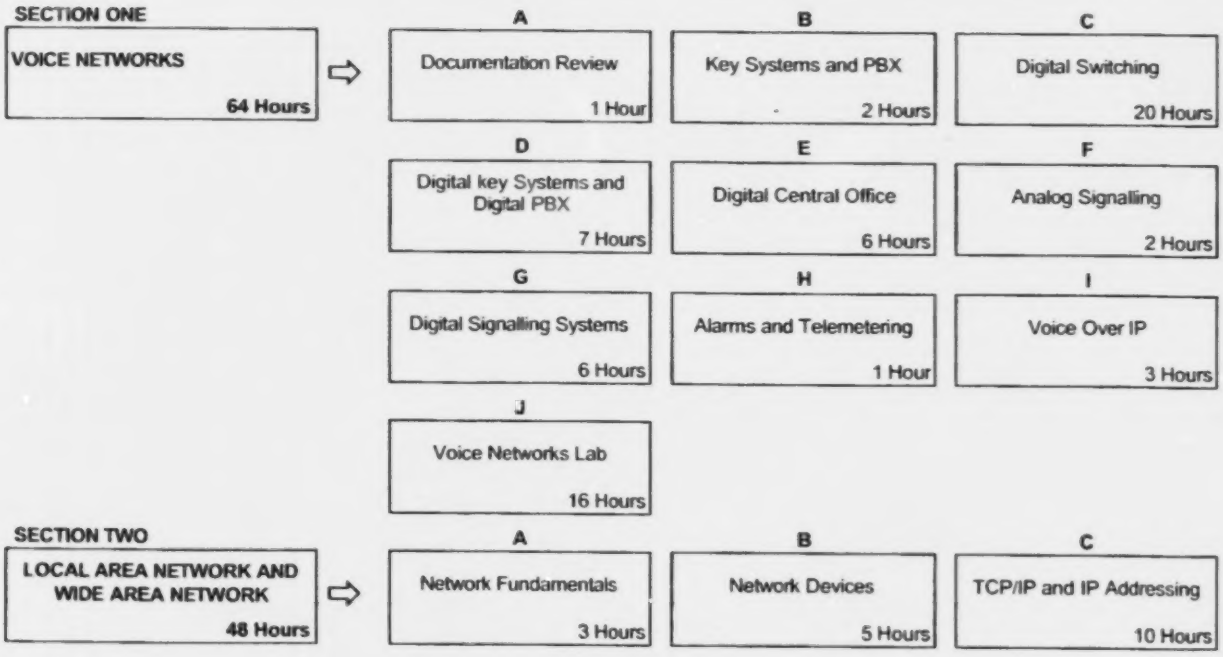
SECTION THREE

NOISE MITIGATION
24 Hours

A	B	C
Introduction 1 Hour	Basic Noise Types 1 Hour	Noise Measurement 2 Hours
D	**E**	**F**
Noise Sources 2 Hours	Influencing Factors 4 Hours	Telephone and Power Line Balance 2 Hours



Fourth Period
(240 Hours)



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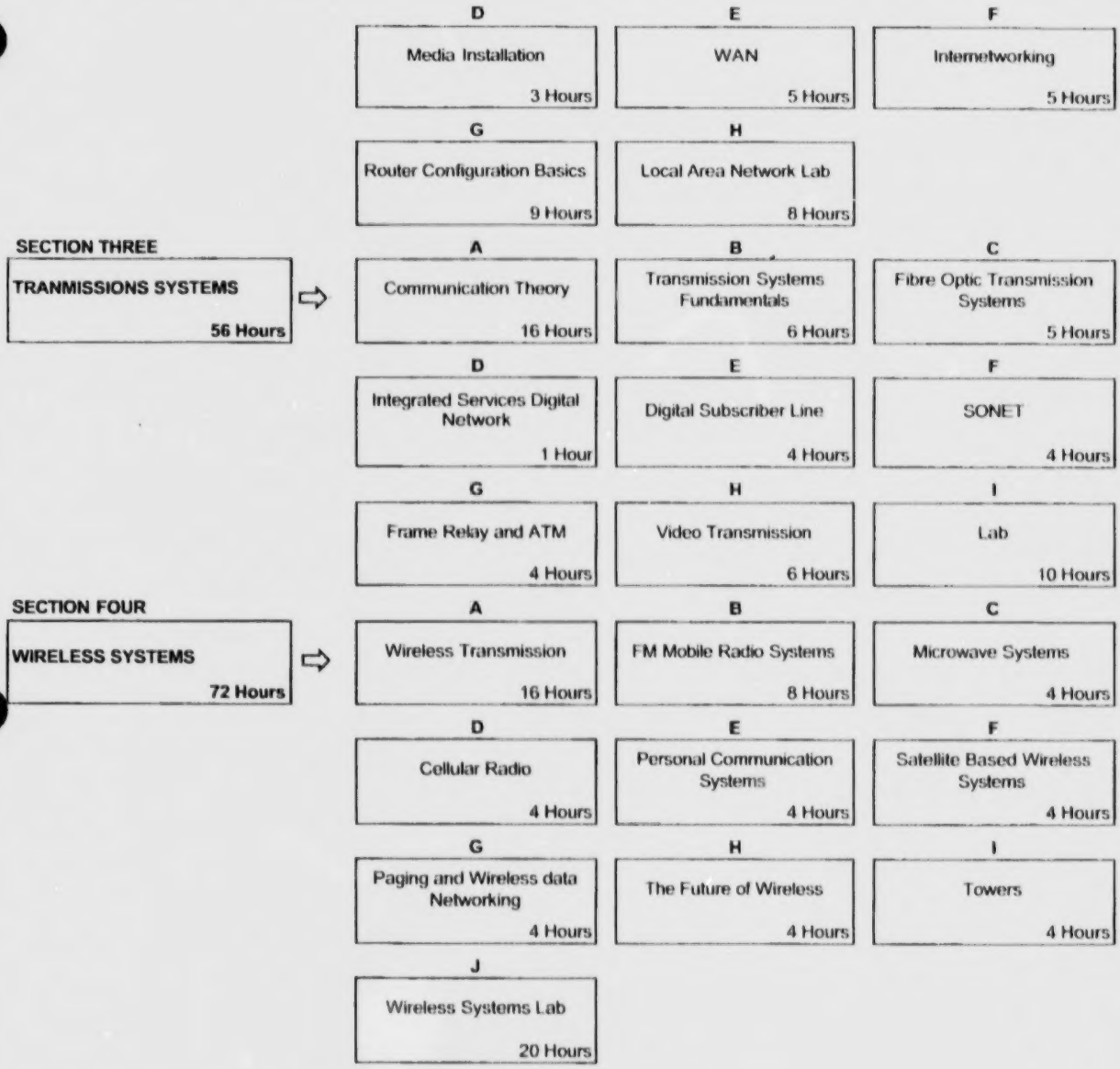

D
Media Installation
3 Hours
E
WAN
5 Hours
F
Internetworking
5 Hours
G
Router Configuration Basics
9 Hours
H
Local Area Network Lab
8 Hours
SECTION THREE
TRANMISSIONS SYSTEMS
56 Hours
A
Communication Theory
16 Hours
B
Transmission Systems Fundamentals
6 Hours
C
Fibre Optic Transmission Systems
5 Hours
D
Integrated Services Digital Network
1 Hour
E
Digital Subscriber Line
4 Hours
F
SONET
4 Hours
G
Frame Relay and ATM
4 Hours
H
Video Transmission
6 Hours
I
Lab
10 Hours
SECTION FOUR
WIRELESS SYSTEMS
72 Hours
A
Wireless Transmission
16 Hours
B
FM Mobile Radio Systems
8 Hours
C
Microwave Systems
4 Hours
D
Cellular Radio
4 Hours
E
Personal Communication Systems
4 Hours
F
Satellite Based Wireless Systems
4 Hours
G
Paging and Wireless data Networking
4 Hours
H
The Future of Wireless
4 Hours
I
Towers
4 Hours
J
Wireless Systems Lab
20 Hours

FIRST PERIOD TECHNICAL TRAINING
COMMUNICATION TECHNICIAN TRADE
COURSE OUTLINE

TOPICS	OBJECTIVES Upon successful completion of this unit the apprentice should be able to:
SECTION ONE: ..... TRADE INTRODUCTION/SAFETY/WORKPLANS ..... 8 HOURS	
A. Trade Scope ..... 0.5 Hours	
1. Past	1. Describe the telecommunication industry history.
1. Present	1. Describe the present telecommunication environment.
1. Future	1. Identify emerging technologies, trends, and opportunities.
B. Personal Safety ..... 1 Hour	
1. Personal protective equipment	1. Describe the application of the following personal protective equipment: a) eye protection b) safety headgear c) filters and masks d) clothing e) foot wear f) gloves
2. Equipment	1. Describe the application of voltage testing equipment. 2. Describe the application of gas detection equipment. 3. Describe the care and use of ladders. 4. Describe the care and use of climbing gear.
3. Responsibilities	1. Describe employer and employee responsibilities regarding personal safety.
C. Hazardous Materials ..... 1 Hour	
1. WHMIS	1. Describe the function and purpose of MSDS. 2. Describe the function and purpose of TDG. 3. Identify WHMIS labels.

		4. Describe the disposal of hazardous goods.
2.	Flammable materials	1. Describe safety precautions associated with propane.
		2. Describe the characteristics of propane.
		3. Describe the storage of propane.
		4. Describe the maintenance of propane cylinders, gauges and hoses.
		5. Be aware of transportation procedures for propane.
		6. Describe safety precautions associated with acetylene.
		7. Describe the characteristics of acetylene.
		8. Describe storage of acetylene.
		9. Describe the maintenance of acetylene cylinders, gauges and hoses.
		10. Be aware of transportation procedures for acetylene

D. Confined Space Entry..... 1.5 Hours

1.	Definition	1. Define confined space.
		2. Identify types of confined space hazards: a) oxygen deficiency b) explosive gases c) toxic gases
3.	Gas detectors	1. Identify common types of gas detectors.

E. Trenching..... 0.5 Hours

1.	Definition	1. Define trench.
		2. Identify/describe government regulations.

F. Fall Arrest..... 0.5 Hours

1.	Definition	1. Define fall arrest.
		2. Identify/describe government regulations.

G. Work Plans..... 3 Hours

1.	Drawings	1. Introduction to outside plant work plan drawings.

	2. Documentation	1.	Introduction to outside plant documentation.

SECTION TWO:..... BASIC ELECTRICITY ..... 104 HOURS

A. Electricity Fundamentals .....3 Hours

1.	Introduction	1.	Describe practical applications of the general principles of electricity.
		2.	Explain the importance of trade terminology.
		3.	Describe the components of basic circuits.
2.	Polarities	1.	Explain the relationship between negative and positive polarities.
3.	Structure of atom	1.	Describe the structure of the atom.
4.	Terms	1.	Define, give symbols, and state units of measurement for the following electrical terms: a) coulomb as a unit of charge b) volt as a unit of potential difference c) amp as a unit of current d) ohm as a unit of resistance
		2.	Describe the term closed circuit.
		3.	Describe the term open circuit.
		4.	Describe the term short circuit.
		5.	Describe the term conductance.
		6.	Explain direction of current: a) electron flow b) conventional flow
5.	Electrical sources	1.	Identify sources of electricity.
		2.	Describe the difference between alternating current and direct current.

B. Ohm's Law .....3 Hours

1.	Relationships	1.	Describe the direct relationship between V & I.
		2.	Describe the inverse relationship between I & R.
		3.	State the forms of Ohm's Law.
2.	Calculations	1.	Perform calculations using all forms of Ohm's Law.
		2.	Perform calculations using multiple and sub-multiple units for:

a) current
b) voltage
c) resistance

3. Power

1. Explain power dissipation and work in a resistance.
2. Calculate power dissipation in a resistance.
3. Explain the relationship between voltage, current, resistance and power.
4. State forms and perform calculations using power formulas.

C. DC Circuits..... 18 Hours

1. Series

1. Define series circuits.
2. Calculate and Analyze the following for series DC circuits:
   a) current
   b) total resistance
   c) voltage drops
   d) power
   e) equivalent circuits
   f) describe voltage dividers
   j) explain polarity of IR voltage drops
3. State Kirchhoff's Voltage Law.
4. Describe the effects of an open on a series circuit and troubles in a series circuit

2. Parallel

1. Define parallel circuits.
2. Calculate and Analyze the following for parallel DC circuits:
   a) common voltage/voltage drops
   b) branch currents
   c) total current
   d) resistors in parallel
   e) total resistance
   f) conductance
   g) power
   h) equivalent circuits
3. State Kirchhoff's Current Law.
4. Describe current dividers
5. Troubleshoot the effects of opens and shorts on a parallel circuit.
6. Draw parallel circuits.

3. Series/parallel

1. Define and Identify series/parallel circuits.
2. Calculate and Analyze the following for series/parallel DC circuits:
   a) total resistance
      i) resistance strings in series

ii) resistance strings in parallel circuits
iii) resistance strings in series-parallel circuits

b) current division
c) voltage division
d) conductance
e) power
f) equivalent circuits

3. State Kirchhoff's Laws as related to a series/parallel circuit.

4. Troubleshoot the effects of opens and shorts on a series/parallel circuit.

5. Draw series/parallel circuits.

6. Describe wheatstone bridge.

7. Describe chassis ground.

8. Describe voltage to chassis ground.

D. Analytical Troubleshooting ..... **2 Hours**

1. Definition
   1. Define analytical troubleshooting.

2. Problem
   1. Describe analytical problem solving techniques.

3. Cause
   1. Identify causes against known standards or specifications.
   2. Explain how multi-problem resolutions are accomplished through analytical troubleshooting techniques:
      a) isolating
      b) prioritizing
      c) resolving

4. Verification
   1. Identify methods of verification.

5. Solution
   1. Identify methods of problem resolution.

E. Direct Current Meters ..... **4 Hours**

1. Types
   1. Identify and describe the following types of analog and digital DC meters:
      a) moving coil meters
      b) voltmeters
      c) ohmmeters
      d) multimeters
      e) ammeter
   2. Describe the construction of the following analog DC meters:
      a) voltmeters
      b) ohmmeters
      c) multimeters

2. Operation	1.	Explain the operation of analog and digital DC meters.
3. Application	1.	Describe common applications for analog and digital DC meters.
	2.	Describe the use and application of meter shunts.

F. Conductors/Insulators ..... 2 Hours

1. Conductors	1.	Explain the purpose and function of conductors.
	2.	Identify the types of conductors.
	3.	Explain AWG.
	4.	Explain the effect of wire resistance in a circuit.
	5.	Describe standard hardware: a) switches b) fuses c) pilot lamps
2. Insulators	1.	Explain the purpose of insulators.
	2.	Identify and describe the types of insulators.
	3.	Explain Insulator discharge current.
3. Semiconductors	1.	Describe electron and hole charges in semiconductors.

G. Resistors ..... 2 Hours

1. Types	1.	Describe types of resistors.
	2.	Describe applications for various resistors.
2. Ratings	1.	Understand and use resistor colour code.
	2.	Explain resistor tolerance.
	3.	Identify resistor power rating.
	4.	Select appropriate resistors for circuits.
3. Typical problems	1.	Identify common resistor problems.

H. Batteries ..... 3 Hours

1. Function	1.	Describe the function and operation of the following batteries: a) primary cell b) secondary cell c) voltaic cell d) dry cell

e) lead/acid cell
f) other cells

2. Characteristics

1. Explain specific gravity as related to batteries.
2. Explain internal resistance of batteries.
3. Explain internal resistance of generators.

3. Load matching

1. Match load resistance to generator.

I. Magnetism ..... 4 Hours

1. Magnetic field

1. Define the following magnetic terms:
   a) magnetic field
   b) magnetic flux
   c) flux density
   d) induction by magnetic fields
   e) reluctance
2. Understand and use the following magnetic units:
   a) Ampere/turns
   b) field intensity
   c) Ohm's Law of magnetic circuits
   d) hysteresis
3. Explain the effects of an air gap on a magnet.

2. Magnets

1. Identify the types of magnets:
   a) permanent
   b) electromagnet
2. Identify the types of magnetic material:
   a) paramagnetic
   b) ferromagnetic
   c) diamagnetic
3. Define permeability.
4. Explain magnetic shielding.

J. Induction ..... 3 Hours

1. Induced current

1. Describe the magnetic field around a conductor carrying electric current.
2. Identify the magnetic polarity of a coil.
3. Explain the motor action between two magnetic fields.
4. Explain the induction of current.
5. State Lenz's Law.

2. Induced voltage	1.	Explain the generation of induced voltage.
	2.	Explain motor action.
	3.	Explain Faraday's Law of induced voltage in terms of: a) amount of flux b) number of turns c) rate of cutting

K. Relays ..... 2 Hours

1. Components	1.	Identify and describe relay components.
	2.	Explain relay contact operation.
	3.	Explain relay windings: a) same direction b) differential c) non-inductive
2. Operation	1.	Describe the operation of relays.

L. Alternating Current & Voltage ..... 6 Hours

1. AC generators	1.	Define alternating current.
	2.	AC applications.
	3.	Describe an alternating voltage generator.
	4.	Plot and use a sinewave to describe the relationship between current, voltage and time.
	5.	Describe voltage and current values for a sinewave: a) peak value b) average value c) root mean square value
	6.	Identify and state frequency, period and wavelength of a given sinewave.
	7.	Explain/Identify the phase angle between voltage and current.
	8.	Explain the time factor as related to frequency and phase.
	9.	Describe the effects of resistance on AC circuits.
2. Sources of AC	1.	Identify sources of sinusoidal AC wave forms: a) motors and generators b) 60 Hz AC power line
	2.	Identify and describe sources of non-sinusoidal AC wave forms.

3. Harmonics	1.	Explain the effect of harmonic frequencies on AC circuits.

M. Inductive Circuits.....6 Hours

1. Inductance	1.	Define the unit and symbol for inductance.
	2.	Describe induction by alternating current.
	2.	Describe typical inductors: a) chokes b) transformers
	4.	Describe self-inductance.
	5.	Explain self-induced voltage.
	6.	Explain how the induced voltage opposes a change in voltage.
	7.	Explain the wave shape of V_L induced by sinewave current.
	8.	Explain the current and voltage phase relationship in series and parallel circuits.
	9.	Define variable inductance.
	10.	Calculate the addition between inductances in series and parallel.
	11.	Describe the effects of stray inductance and capacitance.
	12.	Identify and troubleshoot common problems with inductors.
2. Transformers	1.	Explain mutual inductance.
	2.	Describe the ideal transformer.
	3	Identify types of transformers: a) power transformer b) AF transformer c) RF transformer d) step-up transformer e) step-down transformer f) isolation transformer
	4.	Describe operation of transformers.
	5.	Identify types of cores.
	6.	Describe types of core losses.
	7.	Explain use of transformer for impedance matching.
3. Inductive reactance	1.	Describe X_L in terms of an AC resistance (impedance) called inductive reactance.

		2. Calculate X_L, L and frequency given any two of the variables.
		3. Add inductive reactances in series and parallel.
		4. Perform Ohm's Law calculations with X_L.
		5. Identify applications of inductive reactance.
4.	Inductive circuits	1. Calculate the effect of inductive reactances and resistances in series and parallel circuits.
		2. Explain the term "back EMF".
		3. Calculate L/R time constant.
		4. Describe the hazards associated with the high voltage produced by opening RL circuits.
		5. Perform a comparison of time constant and reactance.

N. Capacitive Circuits ..... 6 Hours

1.	Capacitance	1. Define the unit and symbol for capacitance.
		2. Explain how charge is stored in a dielectric.
		3. Explain the charging and discharging of capacitors.
		4. Describe typical capacitors: a) electrolytic b) bipolar
		5. Calculate capacitor value using: a) colour code b) number system
		6. Explain how AC voltage produces AC current in a capacitive circuit.
		7. Explain the current and voltage phase relationship in series and parallel circuits.
		8. Calculate and explain the relationship between capacitances in series and parallel.
		9. Describe the effects of stray inductance and capacitance.
		10. Identify and troubleshoot common problems with capacitors.
2.	Capacitive reactance	1. Describe X_C in terms of an AC resistance (impedance) called capacitive reactance.
		2. Describe alternating current in a capacitive circuit

		3. Calculate X_C, C and frequency given any two of the variables
		4. Add capacitive reactances in series and parallel.
		5. Perform Ohm's Law calculations with X_C.
		6. Identify applications of capacitive reactance: a) voltage dividers b) coupling capacitors
3.	Capacitive circuits	1. Explain sinewave charge and discharge current.
		2. Calculate and explain the effect of capacitive reactances and resistances in series and parallel circuits.
		3. Calculate and explain RC time constant and wave shapes.
		4. Describe long and short time constants.
		5. Describe the universal time constant graph.
		6. Compare time constant and reactance.
		7. Describe RC phase shifter circuit.

O. RLC in AC Circuits ..... **4 Hours**

1.	Ohm's Law	1. Perform Ohm's Law calculations with the following: a) AC resistive circuits b) AC inductive circuits c) AC capacitive circuits d) AC circuits with opposing reactances e) AC circuits with reactance and resistance in series and parallel circuits.
2.	Power	1. Perform power calculations: a) real b) reactive c) apparent
3.	Phasors	1. Describe phase relationships in LR, CR, and LRC series and parallel circuits.
		2. Calculate phasors in AC circuits.
		3. Explain AC maximum power transfer.

P. Resonance ..... **4 Hours**

1.	Definition	1. Describe the resonance effect.
		2. Describe resonance in a: a) series circuit

			b) parallel circuit
		3.	Calculate the resonant frequency.
2.	Q factor	1.	Calculate the Q magnification factor.
3.	Bandwidth	1.	Describe the bandwidth of a resonant circuit.
		2.	Calculate the bandwidth of a resonant circuit.
4.	Tuning	1.	Describe tuning.
		2.	Describe mistuning.
5.	Applications	1.	Analyze series and parallel resonant circuits.
		2.	Explain damping of parallel resonant circuits.
		3.	Choose inductance and capacitance for resonant circuits.

Q. Basic Electricity Lab ..... 32 Hours

1.	Orientation	1.	Describe laboratory rules and procedures.
		2.	Describe the function and operation of bench kits and tools.
		3.	Describe and adhere to lab safety practices.
		4.	Use and verify standard resistor colour code.
		5.	Read schematic diagrams.
		6.	Explain the hazards of electric shock.
2.	Meters	1.	Describe and adhere to safety precautions associated with meters.
		2.	Explain meter error.
		3.	Explain the purpose and use function and range switches.
		4.	Read values on different meter ranges.
		5.	Explain purpose and operation of power supplies.
		6.	Use meters to measure power supply terminal voltage: a) VOM b) TVM c) DVM
3.	Series circuit	1.	Calculate and verify line current.
		2.	Calculate and verify voltages and voltage drops.
		3.	Calculate and verify total resistance and total power.
		4.	Verify Ohm's and Kirchhoff's Laws.

4.	Parallel circuit	1.	Calculate and verify total resistance.
		2.	Calculate and verify line current.
		3.	Calculate and verify branch current.
		4.	Calculate and verify voltage and voltage drop.
		5.	Calculate and verify power and resistance characteristics.
		6.	Verify Ohm and Kirchhoff's Laws.
5.	Series/parallel	1.	Calculate and verify total and branch current.
		2.	Calculate and verify voltage applied to each branch and component.
		3.	Calculate and verify total resistance and power.
		4.	Check resistors for open.
6.	Voltage dividers	1.	Verify characteristics of loaded and unloaded voltage dividers.
7.	Network theorems	1.	Explain Thevenin's theorem.
		2.	Explain super position theorem.
8.	Cells	1.	Describe and follow standard care and application of cells.
		2.	Calculate and verify voltages for cells in series, parallel, or series/parallel aiding or opposing.
9.	Power s upplies	1.	Calculate and verify internal resistance.
		2.	Calculate and verify circuit efficiency.
		3.	Explain conditions for maximum power transfer.
		4.	Describe power supply applications.
10.	Oscilloscope	1.	Describe procedures for use and care oscilloscopes.
		2.	Describe the function and operation of oscilloscope.
		3.	Measure and verify the following using an oscilloscope: a) voltage b) time c) frequency d) phase
11.	Inductors	1.	Monitor the effect of inductance on current in DC and AC circuits.
		2.	Measure and verify X_L.
		3.	Measure and verify back EMF.
		4.	Measure and verify phase relationships between I and V inductive circuits.

		5. Measure the resistance of an inductor.
		6. Verify the effects of an open inductor.
		7. Measure and verify the L/R time constant.
12.	Capacitors	1. Measure and verify value of capacitors.
		2. Monitor the effect of capacitance on current in DC and AC circuits.
		3. Measure and verify X_C.
		4. Measure and verify phase relationships between I and V capacitive circuits.
		5. Verify the effects of an open or shorted capacitor.
		6. Measure and verify R/C time constant.
		7. Measure and verify addition of capacitors in series and parallel.
13.	Series RLC circuit	1. Verify Kirchhoff's Law.
		2. Verify the impedance formula.
		3. Verify the following for series resonance: a) frequency formula b) line current c) impedance and voltage d) characteristics e) applications
14.	Parallel RLC circuit	1. Verify Kirchhoff's Law.
		2. Verify the impedance formula.
		3. Verify the following for series resonance: a) frequency formula b) line current c) impedance and voltage d) characteristics e) applications

SECTION THREE: ..... TRADE MATHEMATICS ..... 24 HOURS

A. Review of Basic Arithmetic ..... 10 Hours

1.	Fractions	1. Perform calculations with common and decimal fractions.

2.	Algebra	1.	Perform the following calculations with the aid of a scientific calculator: a) addition, subtraction, multiplication and division of algebraic terms b) manipulation of positive and negative powers c) manipulation of roots and radicals d) solve algebraic equations with one unknown e) electrical application problems
3.	Percentage	1.	Solve practical percentage problems.
4.	Factoring	1.	Factor whole numbers and fractions.
5.	Ratio and proportion	1.	Solve practical ratio and proportion problems.
6.	Units manipulation	1.	Manipulate different MKS units with application in Engineering.

B. Advanced Topics ..... 6 Hours

1.	Formula manipulation	1.	Perform formula manipulation as applied to basic AC/DC problems.
2.	System of equations	1.	Solve the system of two equations using methods of substitution and elimination.
		2.	Use Kirchhoff's current law to solve series/parallel circuit problems.

C. Trigonometry ..... 8 Hours

1.	Basic trigonometry	1.	Understand basic trigonometric ratios and their inverses.
		2.	Solve the right triangle.
		3.	Solve for angles in a different system of units.
2.	Vectors	1.	Draw vectors in Cartesian and polar coordinates.
		2.	Vector algebra.
		3.	Phase angles in radians.
3.	Vector notation for AC circuits	1.	Phasor notation.
		2.	Example of impedance calculations using phasors.
		3.	Mathematical representation of AC signal.

SECTION FOUR: CABLE THEORY AND LAB 68 HOURS

A. Cable Development 1 Hour

1.	History	1. Discuss the history of cable.
2.	Trends	1. Discuss cable trends and future developments.

B. Cables and Conductors 7 Hours

1.	Cables	1. Describe the design and applications for the following cable types: a) lead b) pic alpeth c) pic pap d) pic S e) pic F f) stalpeth g) pasp h) stal-cel i) cel-peth j) cel-seal k) PVC l) figure 8 cable and wire m) coaxial n) fibre o) MUDD 2. Describe special design applications: a) PCM cables b) armoured cables
2.	Conductors/insulation	1. Describe the following types of conductor insulation: a) polyethylene b) paper c) pulp 2. Describe conductor wire gauge. 3. Calculate resistance for: a) 19 awg b) 22 awg c) 24 awg d) 26 awg
3.	Counting or coding cables	1. Describe methods for counting or coding cables. 2. Describe applications for counting or coding cables. 3. Describe basic colour code: a) even pic b) switchboard c) random count d) fibre

C.	**Splicing Theory**		**14 Hours**
1.	Copper types	1.	Identify and describe the function and use of the following types of copper splices: a) straight splice b) bridge splice c) branch splice d) butt splice
		2.	Describe conductor gauging for branch splices.
		3.	Describe the function and application of twisted joints.
		4.	Explain the reasons and methods for clearing conductor ends.
2.	Set up copper cable	1.	Describe copper cable splicing preparation procedures.
3.	Copper splicing procedures	1.	Explain the theory and procedures of splicing.
4.	Fibre types	1.	Describe the fundamentals of fibre transmission.
		2.	Identify and describe fibre splices: a) fusion b) mechanical
5.	Set up fibre cable	1.	Describe bending and racking procedures.
		2.	Describe fibre cable splicing preparation procedures.
6.	Fibre splicing procedures	1.	Describe the theory and procedures of fibre splicing.
D.	**Cable Loading**		**2 Hours**
1.	Reasons	1.	Explain the reasons for cable loading and deloading.
2.	Effects	1.	Describe the effects of cable loading.
		2.	Describe current and feature services.
E.	**Splice Closures**		**2 Hours**
1.	Mechanical closures	1.	Describe the use of mechanical closures for aerial, buried and underground applications.
2.	Cable sheath repair	1.	Describe cable sheath repair techniques for aerial, buried and underground applications.
F.	**Cable Splicing Lab**		**20 Hours**
1.	Tools and materials	1.	Identify common tools.
2.	Copper splices	1.	Perform pedestal splices.

G. Line Theory ..... **8 Hours**

1.	Conduit and manhole systems	1. Describe common types of conduit and manhole systems.
2.	Underground cable	1. Describe precautions associated with underground cable installation: a) bending radius of cable b) cable and winch line tension
3.	Poles and anchors	1. Identify and describe special pole placing equipment. 2. Explain the facing of poles. 3. Explain the setting of poles including the depth of setting. 4. Explain the removal of poles. 5. Explain pole numbering. 6. Explain pole maintenance. 7. Identify and describe the types of pole anchors. 8. Describe the installation of pole anchors. 9. Describe the guying of poles.
4.	Aerial cables	1. Identify and describe types of aerial cable strands. 2. Describe safety considerations for suspension strand. 3. Describe visual test for safety on suspension strand. 4. Describe weight test for safety on suspension strand. 5. Describe maintenance for suspension strand. 6. Identify and describe types of cable lashers. 7. Describe safety considerations associated with cable lashers. 8. Explain placement of cable and lateral. 9. Explain placement of coaxial cable. 10. Explain replacement procedures for aerial cables. 11. Explain removal procedures for aerial cables.
5.	Distribution wire (aerial)	1. Describe aerial service wire. 2. Describe clearances and separations as indicated by the regulations governing electrical safety.
6.	Buried cable	1. Describe the various methods and equipment for placing buried cable and wire:

a) trenchers
b) ploughs
c) directional bore

7.	Rural and urban construction	1. Identify cable depth and separation for rural and urban construction a) property crossings b) private property c) main highway d) municipal roads e) shoulder f) railway g) line assignments h) utility co-ordination i) environmental impacts and responsibilities

H. Cable Pressurization ..... 10 Hours

1.	Purpose	1. Explain the purpose of cable pressurization.
2.	Procedures	1. Describe the initial procedures and limitations for cable pressurization. 2. Describe the pressurizing system components: a) piping b) air dryer c) monitoring system d) fittings
3.	Pressure testing	1. Explain pressure (flash) testing: a) flanges b) plugs c) gauges d) valves e) pressure testing solution
4.	Cable monitoring	1. Describe the following devices: a) Spartan b) Norscan c) emerging equipment
6.	Buffering	1. Describe buffering techniques.
7.	Test equipment	1. Describe pressure test equipment: a) C pressure gauge b) directional flow indicators c) sonic leak locator
8.	Blocking (damming)	1. Explain blocking theory. 2. Install/test cable pressure dam.

SECTION FIVE:.....BONDING AND GROUNDING.....16 HOURS

A. Bonding and Grounding ..... 10 Hours

1.	Primary objectives of Electrical Safety Regulations	1. Explain the purpose of bonding and grounding. 2. Identify Electrical Safety regulatory bodies governing bonding and grounding of communication facilities.
2.	Bonding	1. Describe the bonding and grounding requirements for the last utility. 2. Describe the types of clamps used to bond or ground service equipment. 3. Describe the procedures to be followed when foreign voltages have been located. 4. Describe the essential protective wear.
3.	Wire size/capacity	1. Calculate ground wire length. 2. Calculate ground wire size.
4.	Atmospheric and power effects	1. Describe the effects of lightning on communication systems. 2. Describe the effects of precipitation static on communication systems. 3. Describe the effects of power systems on communication systems: a) inductive b) resistive c) capacitive
5.	Protective measures and devices	1. Describe construction and co-ordination methods: a) design – strength b) clearance c) separation 2. Describe the purpose of the following devices: a) spark gap b) fuses and fuse links c) tip cables d) grounding medium
6.	Power distribution systems	1. Describe the effects of power distribution systems on outside plant: a) exposed b) unexposed
7.	Ground rods	1. Identify ground rod location. 2. Describe ground rod installation. 3. Describe the use and application of ground rod hardware.

8. Ground electrode	1.	Identify and describe the appropriate ground electrode for a given situation.
	2.	Identify and describe the appropriate grounding method.
	3.	Identify the standard for ground resistance.
	4.	Identify and describe methods used for improving ground resistance.
	5.	Identify and describe the appropriate bonding requirements when required.
	6.	Test for potential on customer side of demarcation line.
9. Protectors	1.	Describe the use and application of fused protectors.
	2.	Describe the use and application of fuseless protectors.
10. Pole ground systems	1.	Describe pole ground systems: a) multi grounded neutral b) single wire ground return

B. Station Protection ..... 5 Hours

1. Exposed plant	1.	Identify and describe when cable or installation is exposed to lightning.
	2.	Identify and describe when cable or installation is exposed to foreign power.
2. Ground mediums	1.	Identify and describe acceptable ground source.
	2.	Identify and describe acceptable ground mediums and bonding of ground systems.
3. Spark gap protection	1.	Identify and describe different types of spark gap protection.
	2.	Describe the differences between the different types of spark gap protection.
4. Network interface device	1.	Identify and describe NID component parts.
	2.	Describe the function of NID component parts.
	3.	Describe the correct wiring configuration for NID protectors.
5. Station protection requirements	1.	Describe protective devices.
	2.	Identify the appropriate protection devices to protect life and property of subscribers.
	3.	Be aware of the impact of fusing on the protection program: a) cable section fusing b) fusing for unusually high voltages

6.	Safety	1.	Identify the standard maximum measured voltage allowed before stopping work.
		2.	Identify resistance value in Ohms for bonds and grounds.
7.	Grounding and bonding requirements	1.	Identify and describe the communication system bonding and grounding requirements for a power substation.

C. Central Office ..... 1 Hour

1.	Grounding and bonding requirements	1.	Identify and describe bonding and grounding requirements for central office equipment: a) remote sites b) FOTS equipment c) central office locations d) cellular sites e) subscriber carrier

SECTION SIX: ..... TELEPHONY ..... 24 HOURS

A. Basic Telephone Line ..... 2 Hours

1.	Simple telephone line	1.	Draw and explain a simple telephone circuit (telephone to central office).
2.	Complex telephone line	1.	Draw and explain a complex telephone circuit (loop improvement equipment –loop extenders, VFR's, loading schemes).
3.	Line characteristics	1.	Describe cable characteristics.

B. Basic Telephone Set ..... 3 Hours

1.	Components	1.	Identify components of a typical telephone set.
		2.	Explain the theory of operation of the following: a) transmitter b) receiver c) touch-tone pad d) hook switch e) ringer and capacitor f) network (sidetone)
2.	Types	1.	Analyze the circuits for: a) 2500 set b) electronic set c) digital set d) cordless phones e) IP phones

C. Telecommunication Systems ..... 3 Hours

1.	North American network	1. Describe intra-office call systems. 2. Describe inter-office call systems: a) local b) 10 digit local dialing c) LNP 3. Describe numbering schemes: a) North American b) World c) IP addressing 4. Describe the North American switched network: a) five classes of central office b) CCS 5. Describe the long distance market: a) 1 – 800 service b) equal access toll and local access
2.	Block diagrams	1. Draw and explain block diagram of a telecommunication system which incorporates: a) telephone sets b) key equipment c) PABX d) PCN e) cellular/mobile 2. Draw and explain block diagram of a telecommunication system as it relates to multiplex and carrier systems: a) coaxial cable b) copper cable c) HF and VHF radio d) microwave e) satellite f) fibre optics g) next generation networks

D. Basic Switching System Functions ..... 6 Hours

1.	Interconnecting	1. Describe interconnecting.
2.	Functions	1. Describe the operation of the following switching functions: a) alerting b) attending c) information transmitting d) information translating d) busy testing e) conversation f) supervision g) clear & restore

3. Control	1.	Draw and explain block diagrams of a telecommunication system as relating to: a) distribution/concentration/expansion b) distributed vs. common control c) digital common control
4. DC power	1.	Describe DC power requirements of switching systems.

E. Basic Customer Terminal Equipment ..... 2 Hours

1. Block diagram	1.	Describe the operation of basic customer terminal equipment using a block diagram: a) fax machines b) modems c) ACD d) pay phones
2. Evolution	1.	Describe the evolution of basic customer terminal equipment: a) voice over the internet protocol

F. Basic Telephony Lab ..... 8 Hours

1. Telephone lab	1.	Diagnose common problems associated with analog telephones.
	2.	Examine electronic and IP phones.

SECOND PERIOD TECHNICAL TRAINING
COMMUNICATION TECHNICIAN TRADE
COURSE OUTLINE

TOPICS	OBJECTIVES Upon successful completion of this unit the apprentice should be able to:
SECTION ONE: ELECTRONICS ..... 64 HOURS	
A. Introduction ..... 5 Hours	
1. Review of prerequisites	1. Describe Ohm's Law. 2. Explain resistance and reactance. 3. Explain current and voltage sources. 4. Describe Thevenin's theorem.
2. Semiconductor physics	1. Explain the atomic structure of atoms: a) conductors b) insulators c) semiconductors 2. Explain the term doping. 3. Explain the application and use of doping.
3. PN Junction	1. Describe the construction of a PN junction. 2. Describe forward bias. 3. Describe reverse bias. 4. Describe leakage current. 5. Describe breakdown voltage.
B. Diodes ..... 3 Hours	
1. Rectifier diodes	1. Describe the rectifier diode. 2. Explain the diode curve. 3. Explain the term dynamic resistance.
2. Zener diodes	1. Describe reverse resistance. 2. Describe peak inverse voltage. 3. Describe zener diode characteristics.

C.	**Power Supplies**		**4 Hours**
1.	Rectifiers	1.	Describe the function of rectifiers.
		2.	Identify and describe rectifiers typically associated with power supplies.
2.	Clippers	1.	Describe the operation of a typical diode clipper.
3.	Filters	1.	Identify and describe filters typically associated with power supplies.
4.	Voltage regulators	1.	Describe voltage regulators using zener diodes.
D.	**Junction Transistors**		**2 Hours**
1.	Introduction	1.	Explain transistor theory.
		2.	Describe the correct biasing of transistors.
		3.	Identify transistor symbols.
2.	Current relationship	1.	Explain the alpha current relationship.
		2.	Explain the beta current relationship.
3.	Characteristics	1.	Describe cut off current characteristics.
		2.	Describe breakdown voltage characteristics.
		3.	Describe saturation voltage characteristics.
E.	**Transistor Biasing**		**3 Hours**
1.	Base	1.	Describe base bias.
2.	Emitter	1.	Describe emitter bias.
3.	Collector	1.	Describe collector feedback bias.
F.	**Small Signal Amplifiers**		**7 Hours**
1.	Current and voltage gain amplifiers	1.	Explain current gain and voltage gain amplifiers.
2.	Base driven amplifiers	1.	Describe base driven amplifiers.
3.	Emitter driven amplifiers	1.	Describe emitter driven amplifiers.
4.	Characteristics	1.	Contrast and compare the three types of amplifier configurations: a) common emitter b) common collector c) common base

G. Power Amplifiers ..... **3 Hours**

1.	Operating point	1. Describe the operating point.
2.	Types	1. Describe single ended power amplifiers. 2. Describe push-pull power amplifiers.

H. Oscillators ..... **3 Hours**

1.	Theory	1. Describe the theory of operation of oscillators.
2.	Types	1. Describe the operation of the following oscillators: a) RC phase shift b) Wien bridge c) Hartley d) Colpitts e) Crystal

I. Field Effect Transistor (FET) ..... **3 Hours**

1.	Construction	1. Describe the construction of a FET.
2.	Operation	1. Describe the operation of a FET.
3.	Application	1. Describe typical applications of a FET: a) amplifier b) switch 2. Describe a CMOS switch.

J. IC Operational Amplifier ..... **9 Hours**

1.	Transistors	1. Describe the operation and construction of integrated circuit PNP and NPN transistors.
2.	Amplifiers	1. Describe the operation of differential amplifiers. 2. Describe the operation of ideal operational amplifiers. 3. Analyze operational amplifiers.
3.	Circuits	1. Draw and explain block diagrams for the following: a) summing amplifier b) voltage follower c) inverting amplifier d) non-inverting amplifier e) comparator (basic reference hysteresis) f) subtracting amplifier g) active filter h) optic coupler i) voltage regulator

K. Pulse Theory ..... **5 Hours**

1.	Types of waveforms	1. Identify and describe types of waveforms: a) aperiodic b) periodic i) sinusoidal ii) rectangular iii) exponential c) transient
2.	Characteristics	1. Describe the characteristics of pulse waveforms: a) pulse amplitude b) leading edge c) trailing edge d) time period e) pulse repetition frequency f) pulse repetition rate g) pulses per second h) pulse width i) pulse duration j) mark length k) space width l) duty cycle m) mark/space ratio n) rise time o) fall time p) tilt q) average voltage
3.	Harmonic content	1. Describe the harmonic content of waveforms: a) frequency synthesis b) harmonic analysis c) fourier analysis d) square wave distortion e) upper cut-off frequency f) acceptable high frequency g) lower cut-off frequency circuits
4.	Capacitive/resistive	1. Describe the CR circuit operation. 2. Describe the normalized charge/discharge curve. 3. Describe the CR circuit equations.

L. Advanced Electricity Lab ..... **17 Hours**

1.	Lab familiarization	1. Identify and describe common lab equipment. 2. Describe and adhere to proper lab procedures. 3. Demonstrate the proper use of test equipment. 4. Describe and adhere to proper lab safety practices.
2.	Power supplies	1. Measure and verify DC output and ripple.

		2. Compare lab observations to theoretical explanations.
		3. Troubleshoot common power supply problems.
3.	Transistor circuits	1. Identify and describe different transistor biasing arrangements.
		2. Measure and verify terminal voltages and currents.
4.	Common emitter amplifier	1. Measure voltage gain.
		2. Verify phase relations between input and output voltages.
		3. Troubleshoot amplifiers by comparing calculated and measured values.
5.	Oscillator circuits	1. Calculate and measure oscillator frequency.
6.	Operational amplifiers	1. Construct an IC operational amplifier circuit: a) comparator b) inverting amplifier c) non-inverting amplifier
		2. Calculate and measure operational amplifier gain.
		3. Build and test first-order RC active filters: a) low pass filter b) high pass filter c) band pass filter
		4. Calculate and verify bandwidth.
7.	IC regulation	1. Connect an IC regulator to a power supply.
		2. Compare measured and predicted output voltage.
8.	Pulse	1. Measure pulse characteristics.

SECTION TWO:.....APPLIED MATHEMATICS .....24 HOURS

A. Exponents and Radicals .....8 Hours

1.	Exponents	1. Define and explain the meaning of a zero exponent.
		2. Define and explain the meaning of a negative exponent.
		3. Define and explain the meaning of a fractional exponent.
2.	Radicals	1. Simplify radicals.
		2. Add and subtract radicals.
		3. Multiply and divide radicals.
		4. Explain the square root of negative numbers.

		5. Rationalize Radicals.
B. Logarithms		**8 Hours**
1. Logarithms		1. Define logarithms.
		2. Use logarithmic notation.
		4. Explain the rules of logarithms.
		5. Use common logarithms.
		6. Solve logarithmic equations.
2. Decibels		1. Define decibels.
		2. Describe the application of decibels.
		3. Define dBm, dBrn, and applications.
3. Natural logarithm and the exponential function.		1. Define the natural logarithm and its inverse.
		2. Describe properties of natural logarithms and the exponential function.
		3. Describe the application of natural logarithms and the exponential function in LC and RC problems and general decay problems.
C. Complex Numbers		**8 Hours**
1. The j Notation		1. Define j and what it means.
		2. Explain the mathematical rules relating to j.
		3. Define the complex number.
		4. Explain rectangular and polar formats for complex numbers.
		5. Determine the conjugate of a complex number.
2. Algebra of complex numbers		1. Perform addition, subtraction, multiplication and division of complex numbers.
		2. Describe the application of complex numbers in AC circuits.
SECTION THREE:	**BUILDING WIRING SYSTEMS**	**24 HOURS**
A. General Requirements		**1 Hour**
1. Introduction		1. Explain the terms of reference for building wiring systems: a) required standards (EIA/TIA 568)

b) cable bandwidth
c) structured building cabling
d) typical telecom room (closet)

B. Copper Cables ..... 2 Hours

1.	Cable basics	1.	Define and explain: a) noise b) crosstalk c) cable twists d) impedance e) attenuation
2.	Coaxial cable	1.	Define and explain: a) Coax characteristics b) electrical properties c) use in networks
3.	Twisted pair	1.	Define and explain: a) UTP characteristics b) STP characteristics c) ScTP characteristics d) IBM cable types
4.	Physical cable characteristics	1.	Define and explain: a) length b) flammability c) classifications

C. Fibre Optics ..... 1 Hour

1.	Fibre optics basics	1.	Describe the following: a) cable types b) bandwidth c) return loss d) transmitters and receivers d) fibre equipment

D. Connectors and Interconnection Hardware ..... 1 Hour

1.	Termination	1.	Identify and describe copper cable terminations.
2.	Modular jacks and plugs	1.	Identify and describe the following types of connectors: a) data b) 25-pair c) fibre-optic d) coaxial
3.	Panels and blocks	1.	Identify and describe types of panels and blocks: a) patch panel b) punch-down block
4.	Application guidelines	1.	Describe application guidelines.

5. Work area outlets	1.	Describe work area outlets.

E. Networks ..... 1.5 Hours

1. Local area networks	1.	Describe the basic components.
2. Minis and Mainframes	1.	Describe the basic components.
3. PBX's and key systems	1.	Describe the basic components.
4. Convergence	1.	Explain how network devices are integrated.

F. Structured Building Cabling ..... 1.5 Hours

1. Structured building cabling systems	1.	Describe the types of cross connects.
	2.	Describe the types of distribution frames.
	3.	Describe collapsed configuration.
	4.	Describe fault tolerance.
	5.	Explain fundamental installation planning.

G. Installing Cabling Systems ..... 2 Hours

1. Installation guidelines	1.	Describe general cable installation guidelines.
	2.	Describe inter-building cables.
	3.	Explain how to terminate cables.
	4.	Describe building grounding and bonding.
	5.	Explain surge protection.

H. Certifying Cabling Systems ..... 2 Hours

1. Cable testing	1.	Describe component, link and channel testing.
	2.	Describe field testing methods.
	3.	Explain copper certification tests.
	4.	Explain FO certification tests.
	5.	Explain ISO/IEC cable tests.

I.	**Installation Documentation and Administration**		**2 Hours**
1.	Cable documentation	1.	Describe general cable documentation guidelines.
		2.	Describe TIA/EIA-606 standard.
		3.	Describe cable management.
		4.	Describe electronic administration software.
		5.	Describe the convergence of LANs and cabling systems.
J.	**Building Wiring Systems Lab**		**10 Hours**
1.	Cable	1.	Demonstrate cable layout and planning.
		2.	Install FO and copper cable.
		3.	Demonstrate patch panel terminating.
		4.	Maintain workstation outlets.
		5.	Perform cable testing and certification.

SECTION FOUR: LOGIC CIRCUITS 54 HOURS

A.	**Number Systems**		**4 Hours**
1.	Binary	1.	Convert between the decimal and binary number systems.
		2.	Perform addition and multiplication calculations using the binary number system.
2.	Octal	1.	Convert between the decimal and octal number systems.
		2.	Perform addition calculations using the octal number system.
3.	Hexadecimal	1.	Convert between the decimal and hexadecimal number systems.
		2.	Perform addition and multiplication calculations using the hexadecimal number system.
4.	Codes	1.	Describe the following codes: a) Binary Coded Decimal (BCD) b) ASCII c) extended ASCII
		2.	Explain the relationship between the decimal number system and codes.

B. Basic Logic Circuits ..... 20 Hours

1.	Boolean algebra	1. Explain the purpose of Boolean algebra. 2. Perform calculations on simple multilevel functions with Boolean algebra. 3. Explain and use truth tables.
2.	Logic circuits	1. Describe simple logic circuits: a) AND b) OR c) NOT 2. Describe universal logic circuits: a) NAND b) NOR c) XOR 3. Explain advanced multilevel functions.
3.	Karnaugh maps	1. Perform simplifications using Karnaugh mapping.
4.	Flip - flops	1. Explain nand gate S-R circuits. 2. Explain clocked S-R circuits. 3. Explain "D" flip flops. 4. Explain J-K flip flops.

C. Counters, Encoders, Decoders, and Registers ..... 6 Hours

1.	Counters	1. Describe the following synchronous and asynchronous counters: a) simple binary counter b) MSI counter circuits
2.	Encoders and decoders	1. Describe the following encoders/decoders: a) decimal to binary and BCD b) binary BCD to decimal c) MSI coder circuits
3.	Registers	1. Describe the following registers: a) serial in serial out b) serial in parallel out c) parallel in serial out d) parallel in parallel out e) UART

D. Devices ..... 4 Hours

1.	Timers	1. Explain the operation and application of timers (555 timer).

2.	Display devices	1.	Explain the operation and application of an LED.
		2.	Explain the operation and application of seven segment display.
3.	Tristate logic	1.	Explain the operation and application of tristate logic.
4.	Buffers	1.	Explain the operation and application of buffers.

E. Logic Circuit Lab ..... 20 Hours

1.	Lab orientation	1.	Identify and describe common lab equipment.
		2.	Describe and adhere to proper lab procedures and safety practices.
2.	Combinational circuits	1.	Build simple circuits using circuit elements.
		2.	Test circuits.
3.	Flip flops	1.	Build RS and D type flip flops using NAND gates.
		2.	Test RS and D type flip flops.
		3.	Test MSI J-K flip flops.
4.	MSI logic chips	1.	Build and verify the operation of the counter and decoder.
5.	Troubleshooting	1.	Troubleshoot logic circuits.

SECTION FIVE: ..... BASIC TRANSMISSION ..... 54 HOURS

A. Introduction ..... 2 Hours

1.	Telephone network concept	1.	Describe frequency band and power of the following: a) human voice b) message channel c) data, fax, video d) LANs e) CATV f) wireless
		2.	Calculate and explain the relationship between: a) dB and power ratio b) dB and voltage ratio c) dBm and dB relative to a reference

B. Decibels ..... 4 Hours

1.	Definitions	1.	Define the following terms: a) logarithms

b) decibels dB
c) decibel Levels dBm, dBW, dBmV, dBpico

2. Calculate and explain the relationship between:
a) dB and power ratio
b) dB and voltage ratio
c) dBm and dB relative to a reference

2. Meters

1. Describe the use and application of the following meters:
a) level meters (dB/dBm)
b) frequency selective level meter
c) digital dBm meter

2. Describe bridged reading.

3. Describe terminated reading.

4. Identify common errors in readings.

5. Identify and describe meter correction factors.

3. 0 TLP

1. Describe zero test level points and system level measurements.

2. Define the concept of dBm0.

C. Message Channel ..... 1 Hour

1. Purpose

1. Describe the purpose of a transmission system.

2. Describe the following as related to the message channel:
a) level
b) distortion
c) crosstalk
d) echo and singing
e) noise
f) customer expectations

D. Speech and Hearing ..... 1 Hour

1. Energy distribution

1. Describe energy distribution of speech and hearing.

2. Identify and describe the normal receive level at a telephone receiver.

3. Describe the relationship between hearing level and power level.

E. Types of Messages ..... 1 Hour

1. Voice

1. Describe speech characteristics.

2. Describe the basic requirements for voice transmission.

2. Data

1. Describe the characteristics of data.

		2. Describe the basic requirements for data transmission.
3. Music and Video	1.	Describe the characteristics of music and video.
	2.	Describe the basic requirements for transmission.

F. Types of Facilities ..... 1 Hour

1. Function	1. Identify and describe the function and operation of the following: a) paired cable b) coaxial cable c) multiplex and radio d) wave guide e) fibre optics

G. Four-Wire Terminal Networks ..... 4 Hours

1. Attenuators	1. Describe attenuation.
	2. Describe the purpose of attenuators.
	3. Explain the elements of balance and symmetry in Attenuators
2. Types of attenuators	1. Identify and describe characteristics of the following attenuators: a) T b) pi c) L d) square e) H pads
3. Characteristic Impedance	1. Describe Characteristics Impedance.
	2. Describe Insertion Loss.

H. Transmission Lines ..... 8 Hours

1. Wave behaviour of E-M waves	1. Describe wavelength.
	2. Describe velocity factor.
2. Characteristic Impedance	1. Describe the similarities of transmission line and 4-wire terminal networks.
	2. Describe the primary constants of Characteristic Impedance on Characteristic Impedance and attenuation.
	3. Explain the variation of Characteristic Impedance with frequency.
	4. Describe the effect of terminating a line in its Characteristic Impedance.
	5. Describe an impedance mismatch.

		6. Describe the cause and effect of reflection.
		7. Describe how reflection can be reduced.
3.	Propagation constant	1. Describe the information derived from the secondary propagation constants.
		2. Explain how the velocity of propagation decreases and line loss increases with increases in frequency.
		3. Calculate and explain line loss and velocity of propagation on a cable pair.
		4. Identify and describe factors affecting propagation constants.
		5. Describe the following propagation concepts: a) loss b) velocity c) phase shift
		6. Explain loss and velocity on a specific transmission line.
4.	Standing Waves	1. Describe the cause of standing waves: a) open termination b) short-circuit termination c) impedance mismatches d) % reflections e) zero reflection
		2. Describe standing wave ratios.
		3. Describe VSWR and reflection coefficient.
		4. Describe the effects of standing waves.
		5. Describe return loss concepts.
		6. Describe resonant lines.
5.	Coaxial cable	1. Define radiation resistance.
		2. Describe confining a field.
		3. Calculate Characteristic Impedance.

I. Equalization (Amplitude and Delay) ..... 1 Hour

1.	Description	1. Describe function and operation of equalization.
		2. Identify and describe the following types of equalization: a) amplitude b) decay c) attenuation d) phase

	2. Application	1.	Describe common applications of equalization.

J. Loading.....2 Hours

	1. Purpose	1.	Explain the purpose of loading.
		2.	Describe coil spacing and build out capacitors.
		3.	Describe optimum transmission (LG=RC)
		4.	Describe the effects of loading on: a) frequency spectrum b) propagation
	2. Methods	1.	Identify and describe loading schemes.
		2.	Identify and describe transmission limits and causes of limits.
	3. Applications	1.	Describe loading used with VF.
		2.	Compare loaded and non-loaded line characteristics.
		3.	Compare loaded/non-loaded characteristics with the needs of high frequency applications.

K. Hybrid Circuits.....3 Hours

	1. Types	1.	Identify and describe types of hybrid circuits.
	2. Purpose	1.	Describe the purpose of various types of hybrid circuits.
		2.	Describe the principles of operation of various types of hybrid circuits.
		3.	Describe the operation of the transformer hybrid circuit.
	3. Losses	1.	Explain insertion loss.
		2.	Explain hybrid loss.
		3.	Explain trans-hybrid loss.
		4.	Explain return loss and echo return loss.
		5.	Explain singing.
	4. Test tone levels	1.	Explain standard test tone levels for hybrid circuits.
	5. Balancing	1.	Describe balancing a network and compare with balancing aline.

L. Transmission Line Noise ..... 4 Hours

1.	Types and characteristics of noise	1. Describe types and sources of noise. 2. Explain the interfering effects of noise on transmission of speech and data. 3. Describe the types of noise measurements. 4. Explain noise weighting. 5. Describe noise measuring sets. 6. Explain signal to noise ratio concepts. 7. Describe and explain subscriber loop noise measurements. 8. Describe and explain balanced transmission lines. 9. Identify and describe noise units: a) dBrn b) dBrnC c) dBrnCO 10. Describe echo: a) measurements b) singing c) controlling

M. Loop Design Characteristics ..... 2 Hours

1.	Definition	1. Define circuit or loop.
2.	Loop losses	1. Describe loop resistance for switching offices. 2. Describe the relationship between cable size and loop loss.
3.	DC resistance	1. Describe loop design characteristics associated with DC resistance.

N. Basic Transmission Lab ..... 20 Hours

1.	Decibels	1. Perform decibel measurements.
2.	Pads and attenuators	1. Verify Zo and loss characteristics of pads.
3.	Transmission lines and cable characteristics	1. Verify transmission characteristics: a) primary constants b) electromagnetic waves c) characteristics d) attenuation e) radiation resistance

4.	Cable loading	1.	Verify transfer characteristics of loaded and non-loaded lines.
5.	TDR measurements	1.	Perform TDR measurements.
6.	Hybrid theory and practice	1.	Perform decibel measurements for a hybrid circuit.
		2.	Determine insertion loss, hybrid loss and return loss.
7.	Noise measurements	1.	Conduct noise measurements.

SECTION SIX:.....FIBRE OPTICS FUNDAMENTALS .....20 HOURS

A. Introduction to Fibre Optics.....12 Hours

1.	Introduction	1.	Discuss the history of fibre optics.
		2.	Describe information transmission.
		3.	Identify and describe the advantages of fibre optics.
		4.	Contrast and compare copper and fibre.
		5.	Describe safety issues associated with: a) glass fibre b) laser equipment and tools
2.	Light	1.	Describe electromagnetic spectra.
		2.	Describe geometrical optics: a) reflection and refraction b) Snell's Law c) Principle of total reflection d) Fresnel reflection
3.	Optical fibre	1.	Describe optical fibre construction.
		2.	Describe optical fibre classifications: a) multimode step index fibre b) multimode graded index fibre c) single mode step index fibre
		3.	Describe optical fibre Characteristics: a) modal dispersion b) material dispersion c) dispersion shifted fibres d) fibre bandwidth e) numerical aperture and the number of modes f) attenuation, scattering and transmission windows
4.	Fibre optics cables	1.	Describe buffer types.
		2.	Describe inside cables.
		3.	Describe outside cables.

5.	Connectors and splices	1. Describe connector basics and requirements. 2. Identify and describe types of connectors. 3. Describe splices: a) fusion splice b) mechanical splice 4. Describe passive couplers.
6.	Transmission and reception	1. Describe light sources and transmitters: a) LED and laser b) light modulation and basic transmitter topology c) transmitter power rating 2. Describe detectors and receivers: a) PN, PIN and APD detectors b) noise in photo detectors c) basic receiver concepts
7.	The fibre optics link	1. Describe loss budget. 2. Describe bandwidth budget.
8.	Dense wave division multiplex	1. Describe DWDM multiplexers. 2. Describe optical fibre amplifiers.
9.	Fibre optics system	1. Describe fibre optics installations: a) bend radius b) aerial versus direct buried installation c) indoor installation d) patch panels and splice enclosure 2. Describe fibre networks: a) Centralized network b) Distributed network c) Computer system network d) Broadband application 3. Discuss future trends: a) ITL b) FTTC c) FTTH d) FTTB e) VOD
10.	Fibre optical test	1. Identify test equipment 3. Describe standard tests: a) OFSTP-14 b) FOTP-141 c) FOTP-61 3. Describe optical time domain reflectometry. (OTDR)

4. Troubleshoot fibre optics systems and perform acceptance tests.

B. Fibre Optics Lab.....8 Hours

1. Geometrical optics	1.	Measure total reflection.
	2.	Explain Snell's law of refraction.
	3.	Explain Fresnel reflection.
	4.	Explain numerical aperture.
2. Connectorization	1.	Describe hot melt connectors: a) fibre preparation b) installing the connector c) connector polishing d) connector inspection and loss estimation
3. Fibre splice	1.	Prepare fibre.
	2.	Perform a mechanical splice.
	3.	Measure splice loss.
4. Loss budget measurement and OTDR testing	1.	Perform loss budget measurement using light source and power meter.
	2.	Perform OTDR testing: a) understanding of OTDR equipment and the dead zone b) basic OTDR testing i) fibre attenuation ii) splice loss iii) link loss

THIRD PERIOD TECHNICAL TRAINING
COMMUNICATION TECHNICIAN TRADE
COURSE OUTLINE

TOPICS	OBJECTIVES Upon successful completion of this unit the apprentice should be able to:
SECTION ONE: DATA COMMUNICATIONS ..... 88 HOURS	
A. Overview of Data Communications ..... 2 Hours	
1. Components	1. Identify and describe the major components of a basic data communications system: a) data sources b) data encoder (modem transmitter) c) communications channel (telecommunications facility) d) data decoder (modem receiver) e) data terminal equipment f) data communication equipment 2. Explain the function and operation of each component.
B. Communications Coding Structure ..... 8 Hours	
1. Transmission	1. Describe the requirements for analog transmission. 2. Describe the requirements for digital transmission. 3. Describe serial and parallel data transmission. 4. Describe asynchronous and synchronous data transmission. 5. Explain transmission speeds (bit rate and baud rate).
2. Data codes	1. Describe codes: a) ASCII b) EBCDIC
3. Error detection	1. Describe methods of error detection. 2. Describe parity bits as related to ASCII code. 3. Describe VRC , LRC and CRC.
C. Terminals ..... 2 Hours	
1. Types	1. Describe the function of the following terminals: a) PC b) FAX c) printers

2. Describe the purpose for terminal software:
   a) hyperterminal
   b) procomm

D. Electrical Characteristics of Digital Signals ..... 6 Hours

1. Binary digital signals

1. Describe time domain characteristics.
2. Describe frequency domain characteristics.
3. Describe and Analyze rectangular waves:
   a) spectrum analysis
   b) harmonic nulling factor
   c) wave shaping
4. Describe and Analyze types of digital signals:
   a) bipolar
   b) unipolar
   c) return to zero
   d) non return to zero
   e) AMI
   f) Manchester code
5. Explain Nyquist Theorem as applied to data transmission.

2. Multilevel signals

1. Describe time domain characteristics.
2. Describe frequency domain characteristics.
3. Describe increasing data bit rate without increasing baud rate using multilevel signals.
4. Explain Shannon's Communication Theory as related to the effects of noise.

3. Modulation techniques

1. Describe amplitude modulation:
   a) amplitude s hift keying
   b) vestigial sideband
2. Describe frequency modulation:
   a) frequency shift keying
3. Describe phase modulation:
   a) phase shift keying
4. Describe multilevel AC coding techniques:
   a) multilevel phase modulation techniques (QPSK)
   b) multilevel phase and amplitude modulation techniques (QAM)
5. Describe the advantages of phase modulation:
   a) fixed reference detection
   b) differential detection

E Network Access Devices ..... **8 Hours**

1. Modem	1. Describe the function and operation of a modem. 2. Describe basic elements of a modem: a) transmitter section b) receiver section c) control and timing sections 3. Identify and describe types of DCE: a) dial-up modems (internal/external) b) dedicated modem (i.e., line drivers, DSU/CSU, fibre optic modems) c) 2W and 4W 4. Describe the following modem standards: a) V.22 b) V.22bis c) V.32 d) V.42 e) V.42bis 5. Describe modem protocols and their functions. 7. Describe the following types of modem protocols: a) HDX b) FDX c) X-modem/Y-modem/Z-modem 8. Describe error detection and correction techniques. 9. Explain data compression.

F. Communication Links and Modes of Operation ..... **2 Hours**

1. Modes of operation	1. Explain simplex mode of operation. 2. Explain half duplex mode of operation. 3. Explain full duplex mode of operation.
2. Types of data networks	1. Identify and describe the advantages and disadvantages of a switched data network. 2. Describe and compare a point-to-point communications link with a dedicated network. 3. Describe and compare a multi-drop configuration with a dedicated network. 4. Identify and describe the advantages and disadvantages of a dedicated network.

G. Introduction to Data Communication Equipment ..... 2 Hours

1.	Interface standards	1. Describe the functions and types of interfaces: a) modem b) line driver c) others
		2. Describe RS232 (EIA232), EIA422/423 , EIA449 and EIA530.

H. Digital Data Networks ..... 2 Hours

1.	Block diagram	2. Describe the operation of the following digital data networks using a block diagram: a) frame relay b) ATM

I. Protocols ..... 6 Hours

1.	ISO/OSI	1. Describe the seven ISO/OSI layers.
2.	OSI layer 1 (physical)	1. Describe the OSI layer 1 (physical).
3.	OSI layer 2 (data link)	1. Describe the OSI layer 2 (data link): a) character oriented b) bit oriented
4.	OSI layer 3 (network)	1. Describe the OSI layer 3: a) X.25

J. Analog Data Communications Channel ..... 4 Hours

1.	Levels	1. Describe data communication transmission level point (TLP).
		2. Describe data communications data level point (DLP).
		3. Describe transmit and receive levels in a system .
2.	Parameters	1. Describe systematic and fortuitous distortions.
		2. Define and explain attenuation distortion.
		3. Explain attenuation distortion measurement and equalization.
		4. Define and explain envelope delay distortion.
		5. Explain relative envelope delay measurement.
		6. Define and explain impulse noise.
		7. Explain impulse noise measurement.

8. Define and explain phase jitter.

9. Explain phase jitter measurement.

10. Explain phase hit measurement.

K. Bandwidth Manager ..... 8 Hours

1.	Bandwidth manager	1. Describe the operation of the following multiplexers: a) TDM multiplexers b) add/drop multiplexers

L. Communication Networking Techniques ..... 6 Hours

1.	Circuit switched	1. Describe circuit switched networks: a) dial-up b) ISDN (D channel) basic rate
2.	Non-switched	1. Describe non-switched networks: a) intelligent channel banks b) cross connects c) frame relay (connection oriented)
3.	Packet switched	1. Describe packet switched networks: a) X.25 b) ISDN (D channel) primary rate c) frame relay (connectionless) d) ATM

M. Data Lab ..... 32 Hours

1.	Terminals	1. Install and use terminal software.
2.	Digital signals	1. Analyze time and frequency domains.
3.	Analog modulation	1. Analyze time and frequency domains.
4.	Data communications equipment	1. Install and configure V.
5.	RS232	1. Verify signalling handshake and timing.
6.	Analog impairments	1. Measure various circuit impairments.
7.	Simulation software	1. Verify circuit performance through multiple configurations.
8.	Bandwidth manager	1. Configure the bandwidth manager. 2. Configure various circuit options.
9.	Protocol analyzer	1. Perform error testing and data trapping.

SECTION TWO ..... MULTIPLEXING ..... 80 HOURS

A. Introduction to Networking ..... 4 Hours

1. Definition	1.	Define multiplexing.
	2.	Define time division multiplexing (TDM).
2. Purpose	1.	Describe the purpose of multiplexing in telecommunications systems.
	2.	Describe the principles of operation of time division multiplexing (TDM).

B. Simple Toll Circuit Sub to Sub (Digital Multiplexing) ..... 4 Hours

1. Structure of the Public Switched Telephone Network (PSTN)	1.	Describe system elements: a) LATA's b) IXC's c) ILEC's d) CLEC's e) LAN's f) WAN's g) CAN's h) POP's
2. Function	1.	Describe the function of each block in the system.
	2.	Describe the function of each trunk in the system.
3. Transmission mediums	1.	Identify and describe the types of transmission mediums for intertoll trunks and respective VF capabilities: a) point-to-point microwave b) point-to-point VHF/UHF radio c) coaxial cable d) multiconductor cable e) submarine cable f) fibre optics g) satellite

C. Subscriber Interface ..... 4 Hours

1. Subscriber interface	1.	Describe and compare the 2-wire system to the 4-wire system: a) two-wire to four-wire interface b) insertion loss c) hybrid loss d) transhybrid loss
2. Level and impedance	1.	Describe level and impedance requirements: a) transmission levels of the hybrid b) TLP c) level coordination pads d) splitting jacks

3. Noise	1.	Describe noise measurements and noise units : a) dBrn b) dBrnc c) dBrnco d) S/N

D. Basic Signaling ..... 2 Hours

1. Signalling	1.	Describe telephone loop signalling.
	2.	Describe multifrequency signalling.
	3.	Describe E and M signalling.
	4.	Explain dial pulses.
	5.	Describe DTMF.
	6.	Describe the loop to E and M converter.
	7.	Describe common channel signalling.
	8.	Describe the fundamentals of a Signalling System 7 (SS7).

E. Introduction to Digital Multiplexing ..... 4 Hours

1. Characteristics	1.	Describe the characteristics of analog and digital signals.
	2.	Contrast and compare analog signals with digital signals.
2. TDM	1.	Describe the basic principles of time division multiplexing (TDM).
	2.	Contrast and compare time division multiplexing (TDM) with frequency division modulation (FDM).
3. Pulse amplitude modulation	1.	Describe sampling and the Nyquist Sampling Rate.
	2.	Describe pulse amplitude modulation (PAM) signal characteristics.
	3.	Describe problems and limitations of PAM.
	4.	Describe aliasing noise.
4. PCM	1.	Describe the basic functions of pulse code modulation (PCM): a) sampling b) quantizing c) encoding

F. Fundamentals of Pulse Code Modulation (Digital Multiplexing) ..... 6 Hours

1. Basic PCM system	1.	Describe sampling (TX channel).

		2.	Describe quantizing and encoding (TX common equipment).
		3.	Describe regeneration (repeatered line).
		4.	Describe decoding (RX common equipment).
		5.	Describe VF reconstruction (RX channel).
2.	PCM sampler	1.	Describe the PCM sampler.
3.	Quantization	1.	Describe quantizing and quantization noise.
		2.	Explain compromises between noise and bandwidth.
		3.	Describe PCM compandors.
		4.	Explain the compression characteristic curve.
		5.	Describe signal to noise ratio in a non-linear quantizer.
4.	PCM encoder	1.	Describe the PCM encoder.
		2.	Describe the folded binary.
		3.	Describe steps and segments.
5.	PCM signal format	1.	Describe channel word interleaving.
		2.	Describe synchronization bits.
		3.	Describe T1 bit rate and superframe structure.
		4.	Explain robbed bit signalling.
		5.	Describe frame identification.
		6.	Describe PCM terminal timing.
		7.	Describe superframe format.
		8.	Identify and describe the advantages of converting to unipolar from bipolar.
6.	Suppression and limiting	1.	Describe zero code suppression and amplitude limiting.
7.	Advantages and disadvantages	1.	Identify and describe PCM advantages and disadvantages.

G. PCM Channel Bank (Typically Manufactured Digital Multiplexers)..... 10 Hours

1.	PCM channel banks	1.	Describe transmit, receive and signalling arrangements.
2.	DS1 timing	1.	Describe 1.544 Mbps timing generation.
		2.	Describe BITS timing systems.

3. Receive synchronization	1.	Describe receive framing logic.
	2.	Describe receive signalling frame identification.
	3.	Describe out-of-frame detector: a) local alarm (Red) b) waveforms
	4.	Describe bit-2 detector (remote alarm (yellow)).
	5.	Describe synchronization restoration.
4. Terminal alarms	1.	Describe local alarms (yellow).
	2.	Describe remote alarms (yellow).
	3.	Describe power alarms.
	4.	Describe system alarms (red).
	5.	Describe alarm indication signal (blue).
5. Subscriber services	1.	Describe the fundamentals of the following: a) Data Channels b) Sub-Rate Mixing and Partial T1 Lines c) Switched 56 K d) Smart Channel Banks e) ADSL (Vo DSL) f) SDSL g) HDSL (Vo DSL) h) ISDN i) ATM (Vo ATM) j) PCS k) Frame Relay (Vo FR) l) Voice over IP (Vo IP)
6. Test set	1.	Describe the function and operation of DS-1 test sets.

H. Line Codes.....4 Hours

1. Line codes	1.	Describe encoding methods.
	2.	Describe encoding requirements.
	3.	Describe encoding signals: a) AMI b) RZ c) NRZ d) unipolar NRZ e) bipolar NRZ f) unipolar RZ g) bandwidth requirement for different signals h) clock recovery
	4.	Describe AMI violation.

5. Describe binary zero substitution codes:
   a) zero code substitution
   b) B8ZS
   c) B6ZS
   d) B3ZS

I. Fundamentals of T1 Repeatered Lines (Digital Multiplexing)..... 4 Hours

1. T1 repeatered line	1.	Describe T1 transmission cables.
	2.	Describe line repeater operation.
	3.	Describe simplex power feed.
2. T1 line signal characteristics	1.	Describe T1 line signal characteristics.
	2.	Describe the advantages of bipolar transmission.
3. Definitions	1.	Define span through offices.
	2.	Define span line through offices.
4. Block diagram of PCM system	1.	Describe the functions of the following equipment: a) terminal equipment b) line terminating equipment c) repeater line equipment
5. PCM fault locating	1.	Describe the concept of fault identification and location.
6. Testing T1 lines	1.	Conduct and describe performance measurements: a) BPV b) BER c) CRC d) delay time e) jitter f) timing slips g) error seconds h) alarms

J. Digital Hierarchy (Digital Multiplexing)..... 6 Hours

1. Introduction to digital hierarchy	1.	Describe the hierarchy associated with the following digital signals: a) DS0-bit rate-channel capacity-multiplexing facility b) DS1-bit rate-channel capacity-multiplexing facility c) DS2-bit rate-channel capacity-multiplexing facility d) DS3-bit rate-channel capacity-multiplexing facility e) DS1C bit rate-channel capacity-multiplexing facility
2. Introduction to formatting	1.	Describe the formatting of digital line signals: a) synchronization methods b) framing methods c) house-keeping bits d) parity checking

			e) control frames f) sub-frames g) frames
		2.	Describe format tables: a) DS1 signal format b) DS2 signal format c) DS3 signal format d) DS1-C signal format
3.	Cross connect signals	1.	Describe the characteristics of digital cross connect signals.
		2.	Describe digital access cross connect: a) drop and insert b) grooming c) hubbing d) PCM hierarchy with DACS
4.	European E1 carrier	1.	Describe 30 + 2 channel systems.
		2.	Describe synchronization.
		3.	Describe signalling.
5.	International digital hierarchy (SDH)	1.	Describe the fundamentals of international digital hierarchy.
6.	Synchronous digital hierarchy (SONET)	1.	Describe the fundamentals of synchronous digital hierarchy.

K. T3 Line Signal Characteristics ..... 2 Hours

1.	T3 line	1.	Describe T3 line signal characteristics.

L. Higher Order PCM ..... 4 Hours

1.	Plesiochronous Digital Hierarchy	1.	Describe the principles of plesiochronous digital hierarchy.
2.	Synchronous Digital Hierarchy	1.	Describe the principles of synchronous digital hierarchy.
3.	Plesiochronous Multiplexing	1.	Describe the M1-C multiplexer : a) DS1-C multiframe b) housekeeping bits
		2.	Describe the M1-2 multiplexer: a) DS2 multiframe format
		3.	Describe the M2-3 multiplexer: a) DS-3 multiframe format
		4.	Describe DMT-300 System basics

M. Higher Order Digital Transport Systems ..... 4 Hours

1.	Block diagram of higher order digital transport systems	1. Describe the fundamentals of a block diagram for higher order digital transport system. 2. Describe long-haul transport systems. 3. Describe metro transport systems. 4. Describe multi-service access and switching platforms (Cisco/CIENA).

N. Digital Multiplexing Lab ..... 22 Hours

1.	Sampling and signal tracing	1. Measure and verify PAM signal in a terminal. 2. Identify and verify parameters of the PCM line signal of a terminal. 3. Analyze the PCM bit stream.
2.	PCM terminal alignment	1. Measure and verify receive and transmit gains. 2. Measure and verify drop levels. 3. Measure and verify idle channel noise. 4. Measure and verify quantization distortion and noise.
3.	PCM channel banks alarms and signalling system	1. Interpret alarms and verify restoral systems. 2. Test parameters on PCM channel banks: a) signal level measurement b) quantization noise test c) crosstalk test d) signalling test e) adjustment of level coordination pads
4.	PCM channel access	1. Demonstrate drop and insert techniques. 2. Perform maintenance procedures with PCM channel access test sets.
5.	M1-3 multiplexer	1. Investigate alarms and controls of an M1-3 multiplexer.
6.	Bandwidth Management	1. Explain bandwidth management concepts (e.g. Newbridge).

SECTION THREE ..... NOISE MITIGATION ..... 24 HOURS

A. Introduction ..... 1 Hour

1.	Definitions	1 Define and explain noise in relation to transmission:

a) mitigation
b) importance of transmission

B. Basic Noise Types ..... **1 Hour**

1. Noise types and characteristics	1. Define the basic noise types: a) white, thermal, random b) crosstalk c) impulse d) intermodulation e) quantization f) background

C. Noise Measurement ..... **2 Hours**

1. Noise Measurement	1. Define and describe noise measurement: a) dBm & levels b) dBrn c) dBrnC and C filter d) milliwatt supply

D. Noise Sources ..... **2 Hours**

1. Noise sources	1. Define and describe the various sources of noise: a) power major source b) central office power supply c) electromagnetic radiation d) radio frequency interference e) thermal f) electronic devices g) contact noise h) singing i) crosstalk j) distortion k) echo
2. Effects of Noise	2. Identify and describe transient noise sources on communication facilities: a) sheath currents b) induced voltages c) line surges d) static

E. Influencing Factors ..... **4 Hours**

1. AC power systems	1. Explain basic power system design and concepts: a) definitions b) transmission of power c) distribution of power d) power neutrals e) single wire ground return

f) grounding methods
g) return currents

2. Identify and explain power system characteristics:
   a) balanced/unbalanced loads
   b) loss and feedback current
   c) sinewave & harmonics
   d) power abnormalities
   e) transient power
   f) transverse & longitudinal currents

2. Power and lighting
1. Describe influencing factors:
   a) power and lighting

3. Coupling and effects
1. Explain the theory of coupling as related to noise mitigation:
   a) inductive coupling
   b) capacitive coupling

F. Telephone and Power Line Balance ..... 2 Hours

1. Causes
1. Describe the primary factors causing unbalance on power and communication facilities:
   a) capacitive coupling
   b) inductive coupling

G. Transmission Circuits and Telephone Equipment ..... 2 Hours

1. Internal and external equipment
1. Explain the influence of internal and external equipment on noise mitigation:
   a) customer equipment
   b) central office

H. Noise Mitigation Techniques and Devices ..... 2 Hours

1. Devices
1. Identify and describe the devices designed to minimize mitigation:
   a) isolation transformers
   b) noise filters
   c) chokes
   d) drain coils
   e) induction neutralizing transformer
   f) surge protectors

2. Techniques
1. Explain the methods and theory of the following techniques:
   a) single point ground return
   b) equipment shielding and shielding currents
   c) surge protection
   d) grounding, bonding and SPGS
   e) MGN connection multiground & neutral

I. Noise Measurements and Equipment Lab ..... 8 Hours

1.	Equipment	1. Demonstrate the use of noise measurement equipment associated with noise mitigation.
2.	Tests	1. Perform tests associated with noise: a) measure loop parameters using milliwatt supply b) measure battery and rectifier noise c) show noise measurement errors d) perform harmonic distortion measurements e) find faults using artificial trainer f) perform numerous balance and noise tests on live cable

SECTION FOUR ..... DC POWER PLANTS ..... 24 HOURS

A. DC Power Plant Overview ..... 2 Hours

1.	Components	1. Identify and describe the basic components of a DC power plant.
2.	Purpose	1. Describe the purpose of DC Power Plants. 2. Explain AC theory for conversion from AC to DC.

B. Safety Requirements ..... 2 Hours

1.	Regulations	1. List and describe safety regulators and the scope of regulations: a) WHMIS b) Canadian Electrical Code c) Electrical Protection Act 2. Describe the legal aspect of safety.
2.	Practices	1. List and describe battery and rectifier safety considerations. 2. List and describe safety equipment required. 3. Describe general safety rules.

C. Batteries ..... 2 Hours

1.	Components	1. Describe basic battery components.
2.	Theory	1. Explain the theory of battery charging and discharging. 2. Describe the effects of temperature on batteries.
3.	Safety and procedures	1. Describe battery safety rules. 2. Describe methods for inspecting and cleaning batteries.

D.	**Rectifier Operation**		**2 Hours**
1.	Components	1.	Identify and describe basic rectifier components.
2.	Theory	1.	Describe the operation of ferroresonant, SCR, and switch mode rectifiers including controls, alarms, and connections.
3.	Safety and procedures	1.	Describe rectifier safety rules.
		2.	Describe the application of meter shunts in rectifier circuits.
E	**Low Amperage Power Plants**		**2 Hours**
1.	Components	1.	Draw and interpret a basic block diagram of a common low amperage DC power plant.
2.	Theory	1.	Describe the functions of a low amperage power plant control panel and meter shunts.
		2.	Describe how control panel functions are accomplished.
F.	**Medium and Large Amperage Power Plants**		**2 Hours**
1.	Components	1.	Identify and describe the components of medium and large amperage power plants.
2.	Theory	1.	Describe the functions of medium and large amperage power plant control panels.
		2.	Describe how control panel functions are accomplished.
G.	**Secondary Power Plants "Inverters and Converters"**		**2 Hours**
1.	Inverter	1.	Describe the function of an inverter.
		2.	Draw a basic schematic block diagram of a typical inverter and label each component.
2.	Converter	1.	Describe the function of a converter.
		2.	Describe a basic s chematic block diagram of a typical converter and label each component.
		3.	Describe the purpose of a converter common panel.
H.	**Distribution and Alarms**		**2 Hours**
1.	Distribution	1.	Describe the distribution of a DC power plant.

2. Alarms	1.	Describe how alarms from various pieces of equipment can be combined together.
	2.	Explain how rectifier alarms are identified as minor and major.
	3.	Describe how fuse alarms are extended.

I. Power Plant Lab ..... 8 Hours

1. Measurements and adjustments	1.	Perform the following measurements: a) battery float voltage b) battery equalize voltage c) AC distribution voltage d) shunt voltage measurement e) strap test voltage drop f) specific gravity g) individual cell voltage h) temperature i) voltage drop from rectifier to battery string
	1.	Perform the following adjustments: a) rectifier float voltage b) rectifier equalize voltage c) rectifier current limit adjustment d) rectifier alarm adjustments

SECTION FIVE: ..... COMPUTERS ..... 24 HOURS

A. Computer Fundamentals ..... 3 Hours

1. Computer fundamentals	1.	Describe basic computer terminology.
	2.	Identify and describe the basic hardware components in desktop computer and portable laptop systems.

B. System Board Components ..... 6 Hours

1. System motherboard	1.	Identify and describe the physical components on the system board.
	2.	Explain how the system board transports data, follows programming logic, and coordinates the timing and execution of each processing task.
	3.	Explain how to select system boards and CPUs.
	4.	Describe system component upgrade possibilities.
2. BIOS/CMOS configuration	1.	Describe the function of the BIOS.
	2.	Describe the function of the CMOS configuration.

		3. Describe how to change and save CMOS configuration.
3.	Managing hardware resources	1. Describe the principles and configuring of the following: a) IRQs b) port I/Os c) DMAs d) memory addresses
		2. Describe the resource set-up in a Windows environment.

C. Peripheral Components ..... 9 Hours

1.	Floppy disk drives	1. Describe the storage capacities of 3 1/2" drives and ZIP drives.
		2. Describe the installation procedures.
		3. Describe compatibility problems.
		4. Describe the floppy drive structure.
2.	Hard disk drives	1. Describe types of modern IDE/SCSI hard drives.
		2. Describe hard drive maintenance.
		3. Describe hard drive installation.
		4. Describe hard drive structure.
		5. Describe the formatting of hard drives (partitioning and high level formats).
3.	Memory	1. Describe memory types (SDRAM, DDR and RAMbus).
		2. Describe the installation of memory.
4.	Video display hardware	1. Describe video modes.
		2. Describe VGA and SVGA video resolution.
5.	Parallel and serial ports, I/O devices, and network cards	1. Describe the function of a parallel port.
		2. Describe the function of a serial port.
		3. Describe USB and IEEE1394.
		4. Describe the installation of devices using these ports.
6.	Multimedia hardware	1. Describe multimedia cards.
7.	Preventive Maintenance	1. Describe hardware maintenance steps.
		2. Describe software maintenance and virus protection.

D.	**Computer Component Replacement (Desktop and Laptop Systems)**		**6 Hours**
1.	Disassembly procedures	1.	Describe the procedures for disassembly and reassembly of desktop computers.
2.	Main and peripheral component installation.	1.	Describe the procedures for installing devices in a desktop computer.
		2.	Describe the procedures for installing devices in a laptop computer.
		3.	Perform diagnostic tests to verify proper operations.

FOURTH PERIOD TECHNICAL TRAINING
COMMUNICATION TECHNICIAN TRADE
COURSE OUTLINE

TOPICS		OBJECTIVES Upon successful completion of this unit the apprentice should be able to:	
SECTION ONE:	**VOICE NETWORKS**		**64 HOURS**
A.	**Documentation Review**		**1 Hour**
1.	Principles	1.	Review documentation organization.
		2.	Identify and describe types of drawings.
		3.	Describe the systematic usage of documentation.
2.	Sample documentation	1.	Describe the index.
		2.	Describe the organization of sample documentation.
3.	Schematics	1.	Identify and describe digital logic and linear components.
4.	Print reading	1.	Describe the interpretation of standard corporate print types.
B.	**Key Systems and PBX**		**2 Hours**
1.	Basic key systems	1.	Describe the organization of a basic key system.
		2.	Describe the operation of basic key system.
2.	Basic PBX	1.	Describe the organization of basic PBX.
		2.	Describe the operation of basic PBX.
C.	**Digital Switching**		**20 Hours**
1.	Advantages	1.	Describe the advantages of digital switching.
2.	Concepts of time and space switching	1.	Describe the concepts of time and space switching.
3.	Network planning	1.	Describe the following concepts: a) synchronization b) clocking c) elastic buffering
4.	Features and options	1.	Describe the following concepts: a) class of service b) call management services

5.	Packet and circuit switching	1.	Describe packet and circuit switching.
		2.	Describe VoIP fundamentals.
6.	Generic digital central office	1.	Describe the following according to standard block diagram of a digital central office: a) organization b) components c) operation
7.	Switched bandwidth	1.	Describe switched bandwidth in regards to: a) current central office b) SONET - capable central office c) ATM - capable central office

D. Digital Key Systems and Digital PBX ..... 7 Hours

1.	Digital key system operation	1.	Describe digital key system features.
		2.	Describe the operation of a digital key system.
2.	Digital PBX operation	1.	Describe digital PBX features.
		2.	Describe the operation of a digital PBX.

E. Digital Central Office ..... 6 Hours

1.	Peripherals	1.	Describe the operation of peripherals: a) line cards b) trunk cards c) peripheral processor d) remotes
2.	Switching network	1.	Describe the operation of switching networks: a) architecture b) processor c) redundancy
3.	Central control	1.	Describe the operation of central control: a) architecture b) processor type c) redundancy d) message processing
4.	Input/output	1.	Describe the input/output process: a) architecture c) output messages d) alarm response e) auxiliary systems (LAMA)
5.	Call processing	1.	Describe call processing: a) intra-office

			b) inter-office c) toll
	6. Switch maintenance	1.	Describe switch maintenance: a) concept of ongoing analysis b) scheduled versus on demand diagnostics c) software maintenance d) centralized maintenance
	7. Toll network equipment	1.	Describe central office/toll interface.
F.	**Analog Signalling** ..... **2 Hours**		
	1. E and M signalling	1.	Describe the principles of E and M signalling: a) 2W/4W b) types I-IV
	2. Controlled outpulsing	1.	Describe controlled outpulsing: a) delay dial b) wink start
	3. Foreign exchange	1.	Describe the concept of foreign exchange: a) SF signalling b) FXS/FXO
	4. Reverse battery supervision	1.	Describe reverse battery supervision.
G.	**Digital Signalling Systems** ..... **6 Hours**		
	1. Common channel signalling	1.	Describe the concept of CCS: a) CCS7 b) CCS7 applications (CMS)
		2.	Describe the concept of signalling in wireless call processing.
H.	**Alarms and Telemetering** ..... **1 Hour**		
	1. Definitions	1.	Describe alarms and telemetering concepts.
	2. Responsibilities	1.	Describe telecommunication company responsibilities.
		2.	Describe vendor responsibilities.
I.	**Voice over IP** ..... **3 Hours**		
	1. VoIP	1.	Describe basic principles of operation.
		2.	Describe advantages and disadvantages of circuit switched voice.
		3.	Describe advantages and disadvantages of VoIP.

4. Describe existing obstacles.

J. Voice Networks Lab ..... 16 Hours

1. Key system	1.	Install and test an electronic key system.
2. PBX	1.	Install and test basic PBX: a) programming numbers and features b attendant console feature testing c) digital interface
3. Analog signalling	1.	Install and test signalling modules.

SECTION TWO: ..... LOCAL AREA NETWORK AND WIDE AREA NETWORK ..... 48 HOURS

A. Network Fundamentals ..... 3 Hours

1. Introduction to networking	1.	Define networking.
	2.	Discuss the origin of networking.
	3.	Explain the purpose of networking.
2. The OSI reference model	1.	Explain the need for standards.
	2.	Describe the advantages of a layered network model.
	3.	Describe the seven layers of the OSI model.
	4.	Describe the process of data encapsulation.
3. Network terminology	1.	Define the following networking terms: a) client/server b) peer-to- peer c) LAN d) WAN e) MAN f) NOS g) NIC h) network hardware i) network software

B. Network Devices ..... 5 Hours

1. Physical layer	1.	Describe the function of the following layer 1 components: a) network media b) physical components (jacks, plugs, patch panels) c) transceivers d) repeaters e) hubs

		2. Describe LAN physical topologies: a) BUS b) star c) ring
		3. Explain the concept of collision domains.
1.	Data link layer	1. Describe the function of the following Layer 2 components: a) NIC b) MAC addressing c) bridges d) switches e) framing
		2. Describe media access control protocols: a) Ethernet b) Token ring c) FDDI
		3. Explain the concept of broadcast domains.
3.	Network layer	1. Describe the function of routers: a) routing b) network addressing c) network segments d) path determination
		2. Describe the similarities and differences of physical and logical addresses.
		3. Describe the concept of a network cloud.

C. TCP/IP and IP Addressing ..... 10 Hours

1.	Purpose and origin of TCP/IP	1. Describe the origin of the TCP/IP protocol.
2.	TCP/IP protocol suite	1. Describe the function of the application layer of the TCP/IP protocol.
		2. Describe the function of the transport layer of the TCP/IP protocol.
		3. Describe the function of the internetwork layer of the TCP/IP protocol.
		4. Explain the function of the network interface layer of the TCP/IP protocol.
		5. Describe the similarities and differences of the TCP/IP model and the OSI model.
3.	IP addressing	1. Describe the classes of IP addressing.
		2. Explain the process of converting decimal to binary and binary to decimal.

		3.	Describe the purpose network ID's and broadcast addresses.
		4.	Perform the process of subnetting an IP address.
D.	**Media Installation**		**3Hours**
1.	Horizontal cabling standards	1.	Describe horizontal cabling standards for CAT 5 cable.
2.	Wiring closet specificatio	1.	Describe standards for wiring closets as they apply to the following: a) size b) walls c) floors and ceiling d) lighting e) power f) heating and air conditioning g) room and equipment access h) cable access and support
3.	Backbone cabling	1.	Describe the function of the POP, the MDF and the IDF.
E	**WAN**		**5 Hours**
1.	WAN standardization	1.	Describe WAN connection methods: a) connection oriented b) connection less c) packet switched d) circuit switched
		2.	Examine WAN protocols: a) T1 b) frame relay c) ATM d) ISDN
2.	WAN physical layer	1.	Describe the physical layer as it relates to WAN technologies.
F.	**Internetworking**		**5 Hours**
1.	ARP and RARP	1.	Describe how ARP/RARP is used to determine addresses of unknown hosts.
2.	Routed protocols	1.	Describe the characteristics of a routed protocol and the differences between a routed and a routing protocol.
		2.	Identify 3 major routed protocols.
3.	Routing Protocols	1.	Describe the characteristics of the following routing protocols: a) RIP b) IFRP c) EIGRP d) OSPF

e) exterior and interior gateway protocols
f) BGP

G. Router Configuration Basics ..... 9 Hours

1.	Router user interface	1. Describe the methods used to configure a router. 2. Describe user and privileged mode. 3. Describe how to use the help function of a router. 4. Describe the function of the IOS editing tools. 5. Examine and describe the following router modes: a) global configuration b) interface configuration c) router configuration d) line console
2.	Router components	1. Describe the function of the following router components: a) ROM b) flash memory c) NVRAM d) RAM e) router interfaces
3.	Router show commands	1. Describe the function of the router's show commands.
4.	Basic network testing	1. Describe how the following commands are used to test network connectivity: a) ping b) trace route c) telnet
5.	Router configuration methods	1. Describe how the set-up utility can be used to configure a router. 2. Describe how a router can be configured from the command line.

H. Local Area Network Lab ..... 8 Hours

1.	Cables	1. Create and test the following cables: a) straight through b) crossover c) console
2.	LAN construction	1. Configure PC's to communicate on a peer-to-peer network. 2. Identify MAC and IP addresses. 3. Connect two segments via a crossover connection.
3.	Router configuration	1. Configure routers and PC's to communicate across a small network.

SECTION THREE: TRANSMISSION SYSTEMS 56 HOURS

A. Communication Theory 16 Hours

1.	Analog modulation	1. Describe AM basics. 2. Describe FM basics. 3. Describe PM basics. 4. Describe the advantages and disadvantages of analog modulation.
2.	Digital modulation	1. Describe baseband signal basics. 2. Describe the following in respect to modulation: a) FSK b) QPSK c) offset QPSK d) QAM 3. Describe the effects of inter-symbol interference. 4. Describe the advantages and disadvantages of digital modulation: a) noise immunity b) bandwidth consideration

B. Transmission Systems Fundamentals 6 Hours

1.	Overview	1. Describe the basic principles of the following transmission systems: a) radio b) cellular c) microwave d) fibre e) satellite f) cable g) PCS 2. Describe the advantages and disadvantages of the previously listed transmission systems. 3. Define types of signals used on the previously listed transmission systems.
2.	Signal impairment	1. Explain loss in the previously listed transmission systems. 2. Explain interference in the previously listed transmission systems. 3. Define echo control and delay.
3.	Network system interconnection	1. Describe intersystem compatibility. 2. Describe configuration:

a) point-to-point
b) drop/insert
c) star
d) ring

3. Describe interconnection:
   a) DACS

C. Fibre Optic Transmission Systems ..... 5 Hours

1. Fibre optic terminals description	1.	Describe the configuration of fibre optic terminals: a) commercial b) residential
2. Operation	1.	Describe the operation of terminals: a) signal flow b) options
3. Troubleshooting	1.	Describe acceptance procedures.
	2.	Describe maintenance and repair procedures: a) interpret alarms b) replace cards
	3.	Test a system.

D. Integrated Services Digital Network ..... 1 Hour

1. Purpose	1.	Describe the purpose of ISDN.
2. Protocol	1.	Describe communications protocol.
3. 2B + D	1.	Describe 2B + D.
	2.	Explain the purpose of B channel.
	3.	Explain the purpose of D channel.
	4.	Define line rate.
4. Primary rate 23 B + D	1.	Describe primary rate 23 B + D: a) bandwidth allocation b) customer premise equipment
5. BISDN	1.	Describe BISDN.

E. Digital Subscriber Line ..... 4 Hours

1. DSL fundamentals	1.	Contrast and compare voice band and DSL modems.
	2.	Explain DSL terminology.
	3.	Explain speed and distance limitations.

		4. Describe crosstalk and interference.
2.	Types of DSL	1. Describe ADSL.
		2. Describe HDSL.
		3. Describe VDSL.
		4. Describe RADSL.
3.	Transmission techniques	1. Describe CAD.
		2. Describe DMT.
4.	DSL and cable modems	1. Describe the advantages and dis advantages of DSL.
		2. Describe the advantages and disadvantages of cable modems.

F. SONET ..... 4 Hours

1.	Overview	1. Describe the fundamentals of SONET.
		2. Describe multiplexing techniques.
		3. Describe synchronization techniques.
		4. Describe compatibility: a) interfacing with present systems b) interfacing with future systems
		5. Describe the advantages of SONET.

G. Frame Relay and ATM ..... 4 Hours

1.	Frame relay	1. Describe the fundamentals of frame relay.
		2. Describe frame format.
		3. Describe network components and congestion control.
		4. Describe services.
2.	Asynchronous transfer mode (ATM)	1. Describe the fundamentals of ATM.
		2. Describe the protocol reference model.
		3. Describe architecture.
		4. Describe services.

H.	**Video Transmission**		**6 Hours**
1.	TV transmission fundamentals	1.	Describe the fundamentals of TV transmission.
		2.	Describe the following systems: a) PAL b) SECAM c) NTSC
2.	NTSC	1.	Describe synchronization.
		2.	Describe equalization.
		3.	Describe blanking.
		4.	Describe: a) colour b) vertical and horizontal resolution
3.	Baseband video	1.	Describe baseband video.
4.	Broadband video	1.	Describe broadband video.
5.	B-ISDN	1.	Describe B-ISDN.
6.	Digital video	1.	Describe digital video.
7.	Video compression	1.	Describe video compression.
8.	HDTV	1.	Describe high definition TV.
9.	Transport system	1.	Describe video transport systems: a) fibre b) microwave c) coaxial
10.	Transmission standards	1.	Describe video transmission standards.
I.	**Lab**		**10 Hours**
1.	Modulation	1.	Explain the principles of AM and FM.
		2.	Describe the principles of digital modulation.
		3.	Describe ADSL.
		4.	Describe fibre transmission systems.

SECTION FOUR: ..... WIRELESS SYSTEMS ..... 72 HOURS

A. Wireless Transmission ..... 16 Hours

1. Fundamental concepts	1. Discuss the history of wireless communication.
	2. Explain the necessity of modulation in wireless communication systems.
	3. Describe the roles of the transmitter, receiver and channel in a radio communication system.
	4. Describe the differences between simplex, half duplex, and full duplex communication systems.
	5. Describe the need for wireless networks and explain the use of repeaters.
	6. Describe the major types of modulation.
	7. Describe the relationship between bandwidth and information rate for communication systems.
	8. Calculate thermal noise power in a given bandwidth and at a given temperature.
	9. Explain the concept of signal-to-noise ratio and its importance to communication systems.
	10. Describe the radio frequency spectrum and convert between frequency and wavelength.
2. Transmission lines and waveguides	1. Describe 2-wire transmission.
	2. Describe coaxial transmission: a) propagation constant b) power handling
	3. Describe connectors.
	4. Describe waveguide.
	5. Describe stub tuning.
	6. Describe fibre transmission.
3. Radio propagation	1. Describe the propagation of radio waves in free space and over land.
	2. Calculate power density and electric and magnetic field intensity for waves propagating in free space.
	3. Calculate free space attenuation and path loss.
	4. Perform calculations to determine the maximum communication range for line of site propagation.

5. Calculate path loss in a mobile environment and explain how such an environment differs from free space.

6. Describe the use of repeaters to increase communication range.

7. Describe methods to reduce the effects of fading in mobile systems.

8. Describe ground, space and sky wave propagation.

4. Antennas

1. Explain the operation principles of antennas:
   a) radiation
   b) isotropic
   c) dipole
   d) gain

2. Describe polarization.

3. Describe the following types of antennas:
   a) half wave dipole
   b) quarter wave
   c) five-eighths wave
   d) folded dipole
   e) Yagi
   f) log periodic
   g) collinear
   h) orner reflector
   i) semi parabolic
   j) horn

4. Describe the gain, bandwidth and application of each of the previously listed types of antennas.

5. Explain the use of diversity and downtilt in base station antennas

5. RF components

1. Describe VHF/UHF devices and components:
   a) duplexers
   b) combiner
   c) multi couplers
   d) impedance matching
   e) isolators
   f) circulators
   g) matched loads

2. Describe microwave components:
   a) resonant cavity and filters
   b) tees and couplers
   c) impedance matching devices
   d) isolators
   e) circulators

3. Describe matched load.

B. FM Mobile Radio Systems ..... 8 Hours

1.	Conventional FM mobile radio systems	1. Explain a block diagram of FM transceiver: a) bandwidth - single channel b) RF amp c) voltage d) power e) coupling f) mixer g) oscillator h) limiter i) discriminator/detector
		2. Describe squelch circuits.
		3. Describe input/output devices.
		4. Identify and describe types of mobile radio systems: a) simplex b) repeatered c) duplex
		5. Identify and describe types of squelch systems utilized in wireless communication.
		6. Identify and describe types of signalling systems utilized in wireless communication.
		7. Describe methods of using tie lines for remote control of base station transmitters and extending coverage.
2.	Conserving spectrum	1. Describe the trunking concept.
		2. Describe the cellular concept.
		3. Describe digital techniques utilized for conserving spectrum.
3.	Evolution of mobile telephone	1. Describe the evolution of the mobile telephone system GMTS through AMPS.

C. Microwave Systems ..... 4 Hours

1.	Microwave systems introduction	1. Describe basic block diagrams of microwave systems: a) single hop b) multi hop (IF, baseband) c) protection (space diversity, frequency diversity) d) light and heavy route e) FMT/FMR
		2. Identify and describe types of microwave systems.
2.	Specifications	1. Interpret general system specifications.
		2. Interpret RSP (Radio System Plans from DOC).

	3.	Block diagram	1. Explain block diagrams of microwave transmit/receive systems: a) travelling wave tube b) transmitter c) klystron d) bandwidth (baseband/IF, multichannel) e) solid state f) mixer g) detectors
D.	**Cellular Radio** ..... **4 Hours**		
	1.	Introduction	1. Outline the history of personal communications systems up to the beginning of digital radio.
	2.	Analog	1. Explain the operation of North American analog cellular telephone systems.
	3.	Digital	1. Explain the operation of North American digital cellular telephone systems.
E.	**Personal Communication Systems** ..... **4 Hours**		
	1.	Introduction	1. Compare cellular radio with PCS.
	2.	PCS systems	1. Describe the operation of North American personal communication systems. 2. Contrast and compare North American personal communication systems. 3. Describe the methods in which data can be carried on PCS systems.
F.	**Satellite Based Wireless Systems** ..... **4 Hours**		
	1.	Introduction	1. Define and describe the advantages and disadvantages of low, medium and geostationary earth orbits.
	2.	Specifications	1. Explain system specifications: a) C band, uplink, and downlink frequencies b) Ku band, uplink, and downlink frequencies
	3.	Block diagram	1. Describe the basic block diagram for a satellite system.
G.	**Paging and Wireless Data Networking** ..... **4 Hours**		
	1.	Paging systems	1. Describe the operation of several systems used for one and two way paging. 2. Compare paging systems with respect to capabilities and

			complexity.
		3.	Describe the operation of a typical paging system.
2.	Wireless local area networks	1.	Describe the operation of wired ethernet LANs.
		2.	Explain the need for wireless LAN equipment.
		3.	Discuss the IEEE802.11 and Bluetooth standards and identify their applications.
		4.	Explain the need for, and operation of wireless ethernet bridges and modems.
		5.	Describe the operation of infrared LANs and compare them to wired LANs and wireless LANs.
3.	Wireless packet data services	1.	Describe and compare public packet data networks and compare them with other kinds of data communication.

H. The Future of Wireless ..... 4 Hours

1.	Wireless local loop	1.	Describe and compare wireless alternatives to the copper local loop.
2.	Third generation wireless communication	1.	List the third generation wireless requirements and compare them with systems currently available.
3.	Residential microwave communication systems	1.	Describe the difference between MMDS and LMDS and discuss their contribution to the wireless picture.
4.	Convergence	1.	Explain convergence and discuss the place of wireless communication in the future.

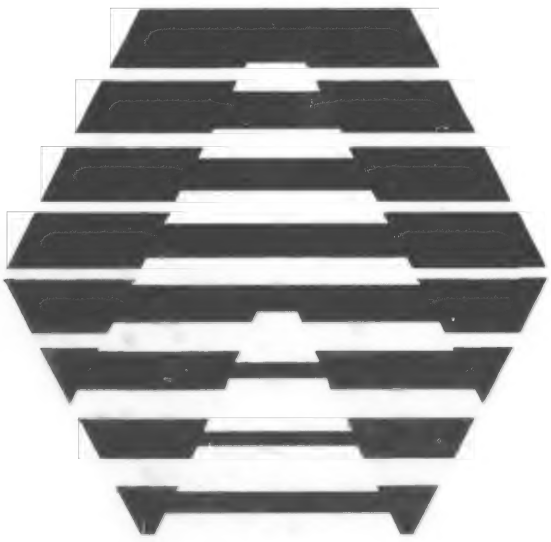
I. Towers ..... 4 Hours

1.	Towers	1.	Describe self-supporting and guyed towers.
		2.	Describe tower anchors.
		3.	Describe tower grounding.
		4.	Describe tower lighting and painting.
		5.	Describe tower safety precautions.

J. Wireless Systems Lab ..... 20 Hours

1.	Mobile radio	1.	Measure the following transmitter characteristics: a) transmit power b) transmit frequency c) transmit deviation

		2. Measure the following transmitter characteristics: a) 20 dB quieting sensitivity b) 12 dB SINAD sensitivity c) modulation acceptance bandwidth
2.	Cellular radiotelephone	1. Place and receive calls.
		2. Enable and disable customer features.
		3. Work through configuration menus.
		4. Work through available service menus.
		5. Use automated testing of cellular radiotelephone with IFR.
		6. Use IFR to monitor activity: a) on local control channels b) on active channels c) of mobile placing a call d) of a mobile receiving a call
3.	Microwave	1. Perform the following measurements: a) VSWR b) power c) antenna gain d) antenna beam width
4.	Satellite	1. Observe and describe C band frequency spectrum: a) LNA output b) block down converter output
		2. Observe and describe polarization of received signals.
		3. Position TVRO antennas.
5.	Path profiling	1. Perform path analysis using path loss software.
6.	Antenna radiation pattern	1. Measure gain, half power beamwidth, and front to back ratio characteristics of a Yagi antenna.



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